LECTURES

ON

PRINCIPLES OF SURGERY

By

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TO

THE MAN AND THE MEN

WHO FOUNDED

THE UNIVERSITY COLLEGE OF MEDICINE

PREFACE.

The subject of Principles of Surgery is one of great importance to both the student and the practitioner of medicine. To the student because it teaches him the etiology, pathology, symptomatology, diagnosis and treatment of surgical diseases and injuries; and to the practitioner because owing to the increase in the field of surgical work it is impossible for him to remember the technique of the various operations devised to meet special indications, and often in emergencies successful practice must be based on a knowledge of primary principles.

Many valuable books have been published on Principles of Surgery, but some are now out of date, some give undue prominence to the writers' personal views, some are incomplete as to the subjects discussed, and some are so exhaustive as to be useful only for reference.

The author does not expect the present modest volume to be free from criticism. It is simply a series of lectures based on standard authorities and is intended for the use of students and practitioners who desire the most recent views of surgical pathology and have not the time or opportunity to read more ambitious works. Any merit the book possesses will be found in the order and system of arrangement and in the clearness and brevity of description.

In preparing the various chapters the text-books of Senn, Nancrede, Parks, Warren, Treves and the systems of surgery edited by Keen and Brayant and Buck have been freely consulted.

STUART McGUIRE.

Richmond, Va., July, 1908.

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LECTURE I.

THEORIES OF DISEASE: HUMORAL THEORY; PHLOGISTIC THEORY; ZYMOTIC THEORY; GERM THEORY—APPLICATION OF GERM THEORY IN MEDICINE AND SURGERY—PRESENT PRACTICAL VALUE AND FUTURE POSSIBILITIES.

Man's earliest conceptions of disease were so clouded by ignorance and superstition that they scarcely deserve mention. The ancient Greeks and Hebrews believed disease to be a blow from an offended deity, while the early Christians considered it a visitation from the devil.

Hippocrates believed the humoral theory of disease, and taught that the body was composed of four humors—blood, phlegm, black bile and yellow bile. A proper proportion of each humor constituted health, and an improper proportion constituted disease. This theory was held for years, but was finally succeeded by the *phlogistic theory.*

The phlogistic theory was based on a supposed analogy between combustion and disease. Physicians saw pestilence strike a community as a spark flames among straw and kindling, attacking person after person as fire would leap from house to house in a city. Chemists, at that time, believed combustion to be due to the liberation of a fluid or essence called phlogiston, which existed in a potential state in all matter. It was inferred that if this were true, there must be some substance in man which when once put in motion acted similarly to phlogiston and spread with deadly effect. This theory was long held and even to the present day remedies which are directed against inflammation or inflammatory conditions are called anti-phlogistics.

The next hypothesis of importance was called the *zymotic theory,* and was based on the apparent similarity between the processes of fermentation and those of disease. It was known that when yeast was added to a solution containing sugar, certain changes occurred. It was observed that a very small quantity of yeast was necessary to inaugurate these changes, that the quantity of yeast was largely increased during the changes, and that the new yeast thus formed would again produce fermentative changes if added to fresh saccharine solutions. It was claimed that infectious diseases presented similar characteristics; that disease was started by the introduction into the body of a substance similar to yeast; that the quantity of the substance was increased during the morbid process, and that the substance was conveyed from the diseased to healthy individuals, reproducing the disease and rapidly diffusing it throughout the community. Confidence in this theory was greatly strengthened when Jenner in 1798 began the use of vaccine virus as a preventive against smallpox. Here the physician had a substance which he could carry about as he could yeast. He could introduce it into the skin of a healthy individual and after a certain period, a disease would man fest itself, just as he could introduce yeast into a solution of sugar and after a certain period find changes due to fermentation. A small amount of either was sufficient, and in each case a certain period of rest was observed before the characteristic changes were seen. Nor did the likeness stop here. It was found that intense heat destroyed the power of yeast; the same was true of vaccine virus. It was also known that when a solution of sugar had once undergone the process of fermentation further changes could not be produced by adding fresh yeast to it. An analogy was found in vaccination, for a person once vaccinated was usually rendered insusceptible to further inoculation by the virus. All these facts furnished to their minds strong proof of the analogy at least as to the mode of operation of the two processes, and the theory was generally accepted.

With the advance of knowledge during the last century, the subjects of fermentation and putrefaction were earnestly studied. Learned men in all parts of the world devoted their lives to their investigation; but it remained for the great scientist, Pasteur, to announce to the world in 1858 their real nature. It had previously been supposed that fermentation and putrefaction were due to the action of oxygen, and were purely chemical processes. Pasteur, however, proved by a series of experiments, the ingenuity and originality of which have rarely been equaled, that they were due to the action of living micro-organisms, and hence were vital processes. There lived at this period in Glasgow a surgeon named Joseph Lister, a man who, despite the demands of an active practice, found time for scientific work. He read with interest the demonstrations of Pasteur and his fellow workers, and at once concluded that their discovery was of far reaching practical value. He reasoned that if fermentation and putrefaction were due to germs, and could be prevented by the exclusion of germs from the test tube, certain diseases, such as suppuration, must also be due to germs, and could be prevented by the exclusion of germs from the wound. With this as a basis, he learned from a series of experiments that an incision made through clean skin by a clean hand, with a clean knife, and protected by a clean dressing, would heal without inflammation and without pus formation. The results of Lister's work were elaborated and published in 1865, and were the origin of the Germ Theory of Disease, which has revolutionized the practice of medicine and surgery.

The application of the principles of the germ theory to the practice of medicine and surgery has been of untold benefit to mankind. In every variety of surgery, suffering is lessened, convalescence shortened, and the lives of millions of patients annually saved. Regions of the body are now safely invaded which were hitherto believed to be inaccessible, and operations are now successfully performed, which if suggested before would have been considered the outcome of a diseased brain or the freak of a disordered imagination. It is difficult for those who visit the hospitals of today and see the comfortable patients in clean and airy wards, with wounds protected by artistic dressings and with faces free from all evidences of pain or fever, to realize the dangers which beset a patient before the aseptic and antiseptic era, or to have any conception of the horrors of a metropolitan hospital of the olden times. As a type of the latter may be cited the Hotel Dieu, of Paris—a hospital whose wards were immediately over the dead house, and whose atmosphere reeked with the odors of putrefaction; a hospital whose only heat emanated from the fevered bodies of its wretched inmates, and whose only ventilation was derived from the accidental defects of its structure; a hospital whose walls were soiled with the expectoration from patients afflicted with every variety of disease and whose floors were covered with blood and pus from virulent wounds. Into this pest-house patients were packed four and six in a bed and in emergencies were placed in cots on tiers one over the other, so that some could only be reached by the use of ladders. It is not surprising that gangrene, erysipelas, and all other contagious diseases, were rife and that one out of every four patients died. Lister is the genius who has wrought the change; the germ theory the agent he employed.

In medicine as well as in surgery the results accomplished have been marvelous. Plagues are prevented; epidemics arrested and contagious diseases are cured. One of the first great discoveries in this department of our art was Pasteur's treatment of hydrophobia by inoculation. In order to study this disease Pasteu produced it artificially in a rabbit by injecting under its ski some virus taken from the mouth of a rabid dog. Wher rabbit died he made an emulsion of its spinal cord and injec into a fresh animal, and the second animal developed hydrophobia. He noticed that the disease in the second animal was more severe than in the first, and further experiments proved that the disease became more severe each time it was reproduced. He concluded that if the virus became more virulent under certain circumstances there must be other conditions which would render it less so. Investigation at length resulted in the discovery of these conditions, and in the production of virus so attenuated that it would not only fail to produce the disease in a healthy animal but would actually protect it from an attack of the disease. A patient who has been bitten by a rabid animal can now be protected from the disease by being inoculated with weakened virus, and hydrophobia, formerly the most horrible and fatal of all diseases, has been robbed of its terrors.

The civilized world was startled not many years ago by the announcement that Koch, of Berlin, had discovered a remedy for tuberculosis, the dread disease that causes the death of one out of every seven people who die. It was a well known fact that no animal could live in its own excreta, and so by injecting the products of the bacillus of tuberculosis into the body of a patient suffering with consumption it was believed the disease would be cured. Koch's lymph or "tuberculin" has proved of little value but it was an advance. Other investigators are now working along similar lines and we may look forward to the result of future experiments with hope and with confidence.

Cancer, the terror of its victim, and of civilization, the *bête noire* of the surgeon, is by some believed to be due to a germ. It has been observed that its advance is frequently checked, and in some instances cured by an accidental attack of erysipelas. Investigation has shown that there is an antagonism between the microbe of erysipelas and the undiscovered microbe of cancer, and deliberate inoculation of erysipelas into a patient afflicted with cancer is actually used in certain desperate and carefully selected cases. Statistics certainly justify further investigation of the subject.

Another advance which the germ theory has accomplished, is in the treatment of diphtheria, a disease which hurries to an untimely grave so many of its victims. The treatment consists in an endeavor to increase the resistance on the part of the system to the action of the germ which produces the disease, by injecting beneath the skin a substance called antitoxin. This substance is prepared by inoculating in a test tube, containing a culture medium, the germs of diphtheria, and allowing them to grow for ten or twelve days, thus saturating the medium with their specific poison or toxin. The contents of the tube are then filtered through a germ-proof filter which removes the microbes but leaves the chemical poison they have produced. A few drops of this solution are injected beneath the skin of a young and healthy horse. The animal becomes very sick. He has high fever, loses flesh and refuses to eat. He recovers in two or three days, and at the end of a week is apparently well. He is then injected again with double the original dose. He is again made sick though not so markedly. This weekly injection of the poison is continued for about six months, the dose being gradually increased until finally the horse is found to have acquired a tolerance to its action and can take enormous doses with no ill effect. The horse has become immune. As soon as this is accomplished the animal's neck is shaved and disinfected, one of the jugular veins is opened and about two gallons of blood withdrawn. This is allowed to cool and after coagulation, the serum is separated from the other constituents. The serum contains the antitoxin and after being carried through a process of concentration is put in a suitable form for use. Before it is put on the market, its power and strength are tested by observing its effect on guinea pigs in which diphtheria has been artificially produced. The action of this agent on diphtheria is remarkable. Used in the early stage in commanding doses it always cures, and only when its employment is too long delayed does it fail.

I have mentioned only a few of the many important results which the practical application of the germ theory has accomplished. Earnest men in all parts of the civilized world are working day and night upon the subject, and no one can predict what the ultimate outcome will be. Perhaps the possibilities are not exaggerated by a French writer, who says: "When man learned to protect himself from wild beasts he made the first step in civilization. Today, man is learning how to defend himself from microbes. It is a step of equal importance. A day will come when in Berlin, in London, in Paris, a man will not die of diphtheria, of typhoid fever, of scarlet fever, of cholera, or of tuberculosis, any more than he dies in these cities today from the venom of snakes or the teeth of wolves."

LECTURE II.

BACTERIA DEFINITION, CLASSIFICATION AND DESCRIPTION OF THREE PRINCIPAL FORMS—MULTIPLICATION OF BACTERIA—CHARACTERISTICS OF SPORES—ESSENTIAL CONDITIONS FOR GROWTH—DISTRIBUTION IN NATURE—CLASSIFICATION OF BACTERIA.

Bacteria, micro-organisms, microbes and germs are synonymous terms applied to certain minute vegetable organisms closely allied to the algæ. For a time, these organisms—some of which possess the power of motion—were thought to belong to the animal kingdom, but it is now known that they belong to the lowest order of the vegetable kingdom, and botanists have made great progress in perfecting a scientific classification. Bacteriacontain no chlorophyl, and are therefore unable to assimilate inorganic substances as do the higher plants; they depend for their food upon living or dead organic matter, obtained from other plants or animals.

From a surgical standpoint bacteria may be divided for study into two classes: *Pathogenic bacteria* and *non-pathogenic bacteria*. The first embraces microbes that produce disease, and the second those which do not produce disease. As examples of pathogenic bacteria may be cited the microbes that cause suppuration and erysipelas; and as examples of the non-pathogenic those which produce fermentation and putrefaction.

Pathogenic bacteria are a menace to health as they may be the exciting cause of disease. Non-pathogenic bacteria are not only harmless but are frequently useful agents. They are employed in domestic economy to produce fermentation as in the manufacture of wine. They also act as scavengers and remove by putrefaction dead bodies that would otherwise encumber the earth. To use a rough simile, one may be likened to the hawk ready to strike and kill; the other to the buzzard able to feed only on the dead. Under certain circumstances, however, so-called non-pathogenic bacteria may become capable of producing or aggravating disease.

Pathogenic bacteria are those that claim our attention. They belong to the class of schizomycetes or fission fungi, and are exceedingly minute in size. Technically, they are said to be from one to four micromillimeters in diameter, but this, of course, conveys little meaning to the student. One writer speaks of them as the "infinite little;" another says they require to be magnified seven hundred times to be seen, and still another states that one thousand could swim abreast through the eye of a cambric needle. Bacteria are composed of a form of protoplasm called mycoprotein, which has the property of being strongly stained by the aniline dyes. They contain no nuclei but are invested with a delicate membrane which appears to be a condensation of the peripheral layers of their protoplasm.

Each bacterium represents a cell, as is made evident by its intrinsic power of germination and reproduction when surrounded by the necessary conditions for its growth. Most bacteria are colorless, but many impart to their media brilliant hues—some red, some yellow, some green and some blue. This is due to a change in protoplasm or to extrusion of granules or pigments. A considerable number of bacteria possess no power of movement. Others are motile and able to change their position. If this power is observed it is generally due to cilia or processes projected from different portions of their bodies, continuous, not with the protoplasm but with the cell membrane, which by a whip-like or lashing movement produce locomotion.

In examining bacteria under the microscope they may be seen singly and widely separated, or they may be seen agglutinated one to the other in a gluey mass, technically known as a zooglea.

PRINCIPAL FORMS OF BACTERIA.

There are three distinct forms of pathogenic bacteria: First, the round (*coccus*); second, the rod-shaped (*bacillus*), and third, the corkscrew (*spirillum*). DeBarry very appropriately compares them to the "billiard ball," the "lead pencil" and the "corkscrew."

The coccus is usually spherical in shape, but sometimes is oval. When cocci occur singly they are called *monococci;* when two are joined like Siamese twins they are called *diplococci;* when a number combine to form a plane they are called *merismopedia;* when they unite to form a cube like a bale of cotton they are called *sarcinæ;* when they group like a bunch of grapes they are called *staphylococci*, and when they adhere one to the other in a single row like links in a chain they are called *streptococci.*

The rod-shaped bacteria known as *bacilli* are usually long and straight, sometimes, however, they are short and may be mistaken for an oval coccus. Occasionally they are slightly undulating in form. In the last instance they are called *leptothrix.*

The corkscrew-shaped bacteria called *spirillæ* take the shape of an arc of a circle or of a spiral; sometimes they resemble a comma. Spirillæ are rarely the cause of disease and practically the surgeon has to deal chiefly with the coccus and the bacillus.

THEORY OF A COMMON BOTANICAL ORIGIN OF BACTERIA.

At one time all bacteria were supposed to have a common origin. It was thought that a bacterium assumed various shapes and was possessed of various properties according to the stage of its development or the influence of its environment. In other words, it was believed that the same germ might at one time be a coccus and at another a bacillus; might under certain conditions cause suppuration and under other conditions tuberculosis. This is now known to be erroneous. In propagation, a coccus always produces a coccus and a bacillus a bacillus. The germ of tuberculosis begets a germ of tuberculosis, and the germ of tetanus begets a germ of tetanus. In other words, bacteria "breed true" and fulfill the law of legitimate succession of cells. Pus and other microbes have been cultivated through thirty generations without suffering any physical deviation or losing any pathogenic properties.

MULTIPLICATION OF BACTERIA.

Bacteria multiply with great rapidity when placed under natural or artificial conditions favorable to their growth. Reproduction takes place by (1) fission, (2) spore formation, or (3) by both of these methods.

Fission, or direct division of a bacterium, is the simplest and most natural way of reproduction. It consists of the elongation of a cell, the constriction of its center, and the formation of a delicate line of cleavage between the two halves. The constriction deepens until finally complete division results. The two daughter cells thus formed, rapidly attain the size of the mother cell and in turn undergo the same process of division.

Spore formation, or sporulation, the second of the two methods, is analogous to the reproduction in higher plant life by the formation of seed. When this process occurs, the first change observed is that the protoplasm of the bacterium becomes granular; next there is the coalescence of these granules at some one point, usually in the center or end of the organism. When coalescence is complete, the spore is formed. Degeneration of the protoplasm of the cell takes place, then rupture of its capsule and the spore is liberated. The spore is invested in a tough capsule and may lie dormant for a long while or may at once undergo development and reproduce a bacterium similar to its parent.

Cocci divide by fission and are incapable of spore production. Bacilli and spirillæ usually divide by fission but sometimes reproduce by spore formation. Under favorable conditions they elect the easier way of direct division, but when the life of their offspring promises to be strenuous they adopt the hardier method of sporulation. Thus certain bacilli always reproduce by fission in the body and by spore formation in the culture tube.

The above facts are important, as a spore owing to its thick investing membrane has much more resisting power to external influences than a bacterium. It has been demonstrated that it requires twice as long exposure to heat to kill a spore as it does to kill an adult germ. Sterilization of material infected by cocci, which as stated do not reproduce by sporulation, can much more easily and certainly be accomplished than in attempting to sterilize the same material infected by spore-producing germs, Fortunately cocci are the most ubiquitous and the most common enemy of the surgeon. When infection with the bacillus anthracis or tetani or other spore-producing germ is suspected, the method of fractional sterilization is resorted to. This consists in subjecting the same material to germicidal heat on three successive days, thus catching the bacteria as they develop from their spores in a state of embryonal vulnerability.

ESSENTIAL CONDITIONS FOR THE GROWTH OF BACTERIA.

Bacteria are plants and require for their growth and reproduction the same conditions as do other members of the vegetable kingdom. The most important are suitable food, temperature and moisture. The food must be organic, as the absence of chlorophyl makes the combination and assimilation of inorganic material impossible. The temperature required varies with the different species of micro-organisms. Some require low, some high temperatures, but most of them grow best between 86° and 104° F. Moisture is also as necessary for their development as other plant life—desiccation retarding growth, although it does not take away the power of germination if water is again supplied. A high temperature kills germs. In fact, heat is the best known disinfectant. Some bacteria are killed at 140° F. others at 180° F. But all species perish when kept at 212° F. for any length of time. Moist heat is very much more efficacious as a germicide than dry heat. Boiling water or live steam will kill any known germ in five minutes. It is a popular opinion that extremely low temperatures will destroy microbic life but this is a fallacy. Cold will arrest the vital activity of bacteria and render them incapable of reproduction or pathogenic activity, but as soon as the temperature is raised to a certain point they become as virulent as ever. Cohn subjected a colony of germs to 180° F. *below* zero, and as soon as the temperature was brought back to a favorable point the germs manifested their vitality. Germs grow best in alkaline and neutral media. Acids inhibit their growth and often act as germicides. Certain drugs, such as bichloride of mercury, carbolic acid, iodine, etc., are germicides and are largely used in surgery, either in watery solutions or in the form of powders. Oxygen is essential to the growth of some species of bacteria and has a prejudicial influence on others. Sunlight and the electric current have a questionable germicidal power.

DISTRIBUTION OF BACTERIA IN NATURE.

Bacteria are widely distributed in nature and, in fact, are found wherever organized life exists. They are present in the air, in water, in clothing, on the surface of the body and in the intestinal canal. They multiply with the most astonishing rapidity. According to good authority if a bacterium divides into two in the space of an hour; into four at the end of the second hour, and into eight at the end of three hours, then in twenty-four hours the number will amount to more than sixteen million. At the end of the second day the product would represent two hundred and eighteen billion, and at the end of three days to forty-seven trillion. Another writer says the bacteria issuing from a single germ would fill the ocean in five days. This statement, however, is theoretical. Fortunately the conditions under which bacteria can grow do not permit practically of such increase.

CLASSIFICATION OF BACTERIA.

The study of the peculiar characteristics of different species of germs has led to certain terms being applied to certain classes. The following definitions will be all that time permits under this head:

1. Saprophytic bacteria are those that live in dead matter.
2. Parasitic bacteria are those that live in living matter.
3. Ectogenous bacteria are those that live outside of the body.
4. Endogenous bacteria are those that live inside of the body.
5. Aërobic bacteria are those that require oxygen for life.

6. Anaërobic bacteria are those that do not require oxygen.

7. Chromogenic bacteria are those which produce color in their growth.

8. Non-chromogenic bacteria are those that do not produce color in their growth.

9. Pyogenic bacteria are those that result in the production of pus.

10. Non-pyogenic bacteria are those that do not result in the production of pus.

11. Aërogenic bacteria are those that produce gas.

12. Anaërogenic bacteria are those that do not produce gas.

13. Motile bacteria are those that possess power of movement.

14. Non-motile bacteria are those that do not possess power of movement.

All the above terms are complicated by the prefix of the adjectives "obligate" and "facultative"—the first indicating that the organism absolutely fulfills the definition; the second, that under some circumstances it may and under others may not comply with it.

LECTURE III.

PTOMAINES AND TOXINS—ENTRANCE OF BACTERIA INTO THE BODY —SOURCES OF INFECTION AND CIRCUMSTANCES INFLUENCING RESULTS—ACTION OF BACTERIA ON TISSUES OF THE BODY— LAW OF POSITIVE AND NEGATIVE CHEMOTAXIS.

Bacteria during their growth and metabolism on organic material, either in the body or in the test tube, produce a chemical poison called a toxin or ptomaine. The exact method by which toxins and ptomaines are formed is not understood. One theory is that the germs form them as a specific secretion or excretion. Another belief is that the germs break up the complex molecules of the organic substance in which they grow, utilize some of the atoms for food, and leave the remaining atoms in a state of imperfect equilibrium. These atoms satisfy their affinity by combining in new molecules and result in the formation of a toxin or ptomaine.

Leaving the theoretical discussion of the manner of formation of toxins or ptomaines, we take up the practical consideration of their properties. Toxins are chemical compounds and as a rule are not affected, as are bacteria, by either heat or germicidal drugs. They produce a poisonous effect on the system in direct proportion to the amount of the dose absorbed, and being a non-vital product are incapable under any circumstances of self-increase as are bacteria. They closely resemble in their action on the economy, certain vegetable alkaloids as strychnine, morphine and atropine. The toxins of different germs produce different symptoms, just as the active principles of different plants have each their peculiar therapeutic action. The toxin of the germ of tetanus acts principally upon the central nervous system causing characteristic tonic and clonic spasms of definite groups of muscles. The toxin of the germ of suppuration causes high fever, rapid pulse and a cadaveric appearance of the skin. The toxin of diphtheria—among other effects—produces paralysis. They also have a definite local effect. Thus the toxins of pus microbes cause the transformation of leucocytes and embryonal cells into pus corpuscles, and the toxin of progressive gangrene directly destroys the protoplasm of the cell body. Toxins are produced in the tissues of the body at the point where the bacteria have effected localization. Owing to their solubility, they are usually rapidly absorbed by the fluids of the body and diffused throughout the system. Nearly all of them act on the higher thermic centers in such a manner as to cause fever.

ENTRANCE OF BACTERIA INTO THE BODY.

Most bacteria are ectogenous, that is, exist and under favororable circumstances multiply outside of the body. Auto-infection is a misapplied term, as practically all infective diseases are caused by the introduction into the body of pathogenic germs from without. Some microbes exist in the soil and owing to sporulation may remain in an active condition for an indefinite time and when an opportunity is offered give rise to endemics of infective diseases. Other bacteria are diffused over wide areas through water courses, as the bacillus of typhoid fever or cholera. Still other microbes, like the pus germ, appear to be everywhere. At one time it was thought that bacteria were conveyed to the body through the medium of the atmosphere and surgeons carefully attempted to sterilize the air of the operating room by means of antiseptic sprays. The danger of this source of infection has now been proven to be small, and the real danger has been shown to come from contact with dirty hands, instruments and dressings. So strong was the conv ction of a noted surgeon on this point that he said: "I would be willing to operate in a water-closet if my hands were only clean."

It has also been demonstrated that most bacteria cannot pass through the unbroken skin, mucous membrane or granulating surface. These structures act as an effective barrier, an impenetrable armor, and unless there is an abrasion or missing link, the germs cannot gain access to the underlying tissues. When an *infection atrium* exists, however, the bacteria find an open gateway to the unprotected cells, and at once pass in and endeavor to assert their pathogenic properties. The character of the reaction that follows infection bears no relationship to the size of the infection atrium but depends on the virulency of the germ and the susceptibility of the tissue. An atrium caused by the prick of a needle in an individual of poor resisting power may be the starting point of an inflammatory condition more grave than that which would follow the infection of a large wound in a patient with normal vital resistance by germs of milder pathogenic powers. After bacteria have entered the body through the broken skin or mucous membrane, the existence of other factors are necessary before they can produce disease. The germs may retain their vitality and circulate in the blood but they cannot exert their specific pathogenic action until they effect localization.

The tissues of the body are not inanimate like an artificial culture medium, but offer a vigorous resistance to the attack of a hostile invader. It is a well known fact that all cases of infection are not followed by pathogenic reaction, and this is due to the ability of the cells to protect themselves against the action of micro-organisms. If, however, from injury or pre-existing disease, the tissues are altered and their vitality impaired so that normal resistance is lessened or abolished, the bacteria can readily effect localization. The existence of a point of lowered resistance in tissue, techinally termed a "*locus minoris resistentiæ,*" is therefore an important point in the issue of the result of bacterial invasion. Numerous experiments have been made which prove the above statement. One consisted in taking two lambs and injecting them with a mild culture of staphylococci. One lamb had his testicles crushed, the other was left uninjured. The injured lamb developed local suppurative inflammation, the uninjured animal escaped. Another experiment consisted in painting one ear of a rabbit with croton oil and leaving the other ear unirritated. Injection of a culture of pyogenic germs at the base of the rabbit's tail, produced characteristic changes in the ear whose resistance had been lowered, while the sound ear remained normal. Remember then, for a germ to gain entrance to the body and produce disease there must be:

1. Infection by contact;
2. Entrance through an infection atrium;
3. Localization at a point of lowered vitality.

SOURCES OF BACTERIAL INFECTION.

It is important that the practitioner know the localities in the body that most frequently harbor germs, in order that their invasion may be anticipated and if possible prevented.

1. *The skin and mucous membrane* are perhaps the most fertile sources of infection. Owing to their constant exposure to the air and contact with infected substances, bacteria are always found on their surfaces. The skin is especially a source of danger as germs not only lodge in and are difficult to remove from recesses such as the folds of the nates or the crevices around the nails, but they also penetrate the structure of the skin through the sweat glands, hair follicles and sebaceous glands. The mucous membranes are constantly bathed with infected fluids, but are protected to some extent by the mechanical and chemical cleansing properties of their normal secretions.

2. *The upper respiratory tract* is also a harbor for bacteria. The mouth, nose, tonsils and pharynx are never free from germs. Abscess of the brain has frequently been directly traced to caries of the teeth. The pneumococcus is commonly present in the saliva. Tuberculosis of the glands of the neck is usually due to invasion through the tonsil.

3. *The alimentary canal* admits of more bacterial infection than any other avenue to the body. Fortunately the acidity of the gastric juice and the relative absence of oxygen in the intestines inhibits the growth of most forms of microbic life. The bacillus coli communis is a usual inhabitant of the bowels in man, and the bacillus of tetanus and of malignant edema can be demonstrated in the alvine contents of herbivora.

4. *The genito-urinary tract* is frequently a source of danger. The healthy urethra and vagina always contain bacteria despite

the fact that normal urine is sterile and that normal vaginal secretion has undoubted germicidal properties.

5. *Milk in the lacteal ducts* is usually sterile but may readily become contaminated at its exit from the nipple. It has also been noted that milk may be infected while in the breast by extension of inflammatory process from the skin.

CIRCUMSTANCES INFLUENCING THE RESULT OF INFECTION.

1. *The virulency and the number of germs introduced.* With certain bacteria it is sufficient to infect an animal with a single organism in order to produce death. This indicates that the germ is extremely virulent and the animal very susceptible. Again, inoculation of an animal with a small number of certain bacteria may be harmless; inoculation with a larger number may cause only local disturbances, while inoculation with still larger dosage may cause fatal results.

2. *Infection with a single species of bacteria or with an association of two or more varieties.* Certain bacteria which alone are extremely dangerous, lose their power when combined with other organisms; while again some have their virulency increased by such affiliation.

3. *Hereditary influences* may modify the usual action of germs. There is undoubtedly the transmission from parent to offspring of immunity to certain infectious diseases, and predisposition to others.

4. *The condition of the part inoculated* must be considered. If there is lowered vitality from hyperemia, anemia, the presence of a foreign body, the withdrawal of trophic nerve influence, or other conditions causing local predisposition, the result of infection will be different from that caused by infection with the same species in healthy tissue.

5. *Pre-existing diseases and anatomical conditions due to age* must be considered in estimating the result of microbic infection. Syphilis, gout, scurvy, diabetes and other constitutional diseases exercise a decided influence on the action of microbes. The puerperal state, typhoid fever and other acute wasting

diseases lessen the patient's resistance. Finally, anatomical peculiarities of different ages, such as enlarged and tortuous blood vessels at the juncture of the diaphyses with the epiphyses in the bones of growing children, and the senile changes in the heart and blood vessels of the aged, all offer unusual conditions which are followed by unlooked for results.

6. *The personal habits and environment* of the infected animal or individual must be considered. Diet has much to do with tissue resistance. Rats fed on bread are more susceptible to anthrax than those fed on meat, and artificial immunity produced in other animals is rapidly lost by starvation. Certain drugs which destroy red corpuscles increase susceptibility, and water injected into the circulation lessens the germicidal power of the blood. Extremely hot weather increases the probability of suppuration and dark, damp, poorly ventilated houses notoriously predispose to infection. Certain occupations obviously render the individual liable to certain microbic diseases.

7. *In a limited number of cases infection can be transmitted from mother to fetus*, and this must be borne in mind as an explanation of otherwise inexplicable developments. The placenta is usually regarded as a perfect filter, nevertheless, it is occasionally an ineffectual barrier against micro-organisms. Cases are known where the bacillus of anthrax and pyogenic cocci have passed from the maternal to the fetal blood.

ACTION OF BACTERIA ON THE TISSUES OF THE BODY.

The action of pathogenic bacteria on the system after they effect localization is both local and general. Locally, they produce irritation or inflammation, and constitutionally they cause fever and other symptoms classified under the terms septic intoxication or septic infection. It is not definitely settled how these results are produced. It is probable that they are effected in three ways: First, bacteria by their presence in the organs or tissues of the body act mechanically and impair their functions. As an example of this may be cited anthrax in which the capillaries are often found so full of the specific bacilli that the blood cannot circulate. Secondly, bacteria abstract from the body a part of its essential constituents; for example, albuminous substances, carbo-hydrates, etc. These are not only taken from the fluids of the body, as the blood and lymph but also directly from the protoplasm of the cells. Thirdly, bacteria act by the development of the chemical poisons or toxins previously described, which are rapidly absorbed and diffused throughout the system. By virtue of their ferment-like action they greatly increase tissue-metamorphosis, and acting on the thermic centers cause fever and other constitutional disturbances.

CHEMOTAXIS.

It is a well proven fact that when bacteria infect a part there is an increase in the number of leucocytes in the part. This is due to the attraction exerted by microbes on the white blood cells, causing them to leave certain localities and accumulate in others. This phenomenon is explained upon the assumption of chemotaxis, or the mutual attraction or repulsion possessed by animal cells or vegetable cells for each other, or as in the present case, by an animal cell for a vegetable cell. When an attraction exists between two cells it is called positive chemotaxis. When a repulsion is evinced it is called negative chemotaxis. The simplest and best understood type of chemotaxis is that exhibited in the sporulation of ferns.

LECTURE IV.

RESISTANCE OFFERED BY THE ORGANISM TO THE ACTION OF BACTERIA—METHODS OF STUDYING BACTERIA—ISOLATION OF VARIOUS BACTERIA—KOCH'S LAWS—AGGLUTINATION TEST—PREDISPOSITION AND IMMUNITY TO DISEASE—METCHNIKOFF'S PHAGOCYTIC THEORY—BUCHNER'S ALEXIN THEORY—EHRLICH'S SIDE-CHAIN THEORY—OPSONINS—BACTERIOLYSINS

Having described the different ways in which pathogenic bacteria may enter the body, and after this their local and constitutional action, it remains for us to study the method by which germs are destroyed and how the toxins are neutralized. As the majority of patients who suffer from infectious diseases recover, it is logical to assume that the system has some way of disposing of the micro-organisms and of antagonizing their poisons. That such is the case is proven by the rapid disappearance of microbes from the blood when injected into the circulation of a healthy animal, and by the subsidence of fever and correction of their constitutional disturbances with ensuing convalescence.

RESISTANCE OFFERED BY THE ORGANISM TO THE ACTION OF BACTERIA.

Nature's chief offensive and defensive resources embrace the alexins, phagocytes, antitoxins, opsonins and bacteriolysins. The emunctories are in all cases important as channels of elimination for bacteria, toxins and the toxic substances formed as a result of disordered metabolism. *Alexins* are normally found in the blood serum. They are the most powerful of al nontoxic germicides. They impart to the serum an antiseptic power equivalent bulk for bulk to a 1:10000 solution of bichloride of mercury. Alexins act on microbes chemically and are potent in destructive power. *Phagocytes* are also normally present in the blood, and when suppuration threatens or is in existence, their number is largely increased. They grapple in hand to hand combat with the germs, and, if they are victorious, kill and remove them. *Antitoxins* are not found normally in the blood, but are produced by the organism after infection has taken place. They have no effect on the germs, but on the toxins produced by the germs. An antitoxin combines with a toxin as an acid does with an alkali, neutralizing it and rendering it inert. In many cases, resort is made to the emunctories, and by diarrhea, diuresis and copious sweating—the "critical discharges" of the old authors—the germs and their poisonous products are eliminated.

THE STUDY OF BACTERIA.

Bacteria are studied by means of the microscope, by cultivation, and by inoculation into lower animals. Owing to the minuteness of the organisms and the imperfection of the instruments, small progress was made in the microscopic study of bacteria until the invention of Abbe's condenser, which gives powerful illumination to the field and allows the use of high power lenses. With modern instruments and the use of stains we can readily distinguish the different species.

The cultivation of bacteria is carried on chiefly in test tubes and petri dishes. For their growth they must have the same conditions as other plants, namely, suitable soil, warmth and moisture. The best soils or culture media are animal broths, solutions of sugar, gelatin, blood serum and agar-agar, the latter a jelly-like substance obtained from seaweed. The culture medium is first sterilized by heat to kill any germs that may already be present, and then the bacteria to be studied are transferred to the culture medium by means of a clean needle. The test tube is then plugged with cotton and placed in an incubator, where if maintained at a suitable temperature, in a short time, rapid proliferation will take place. Trained observers can recognize many of the different species by their manner of growth and by the color and other properties imparted to the media.

Much information concerning bacteria has been obtained by inoculating or injecting them into healthy animals and noting the results. An animal such as a rat, guinea-pig, or rabbit is selected, the skin shaved and disinfected and a solution of germs injected with a hypodermic syringe; or an incision is made in the animal's skin and a piece of infected tissue implanted, and the results watched. In three or four days, the specific disease will become apparent. This method is often of great aid to the surgeon in making a diagnosis. If, for instance, a patient has a tumor and a positive diagnosis between syphilis and tuberculosis cannot be made, inoculation will give a certain differential diagnosis, for if a rabbit is inoculated with a piece of syphilitic tissue no symptoms will supervene, whereas if the inoculated tissue be of a tuberculous nature, the characteristic symptoms of tuberculosis will follow.

ISOLATION OF VARIOUS BACTERIA.

Certain diseases are produced by certain germs. The germ of tuberculosis always produces tuberculosis, the germs of suppuration always produce suppuration, etc. Koch has formulated four laws which must be fulfilled by a germ before it can be said to be the specific cause of a disease.

Koch's Laws.—1. The germ must invariably be found associated with the disease.

2. The germ obtained from the tissue of the diseased animal must be cultivated for successive generations and obtained in pure culture in a test tube.

3. The cultivated germ must be capable of reproducing the disease when injected into a healthy animal.

4. The germ must be capable of demonstration in the tissues of the second animal.

AGGLUTINATION TEST.

Since these laws were formulated by Koch, another test has been developed which may give valuable evidence as to the nature of the germ. This is the agglutination test. It is based on the observation that when bacteria are mixed with the blood of a patient who has been recently infected with the same species of micro-organisms, the germs will undergo a clumping and loss of motility, in other words, agglutination. To illustrate the practical value of this test it is only necessary to say that when Shiga isolated the germ of epidemic dysentery the strongest proof he cou'd offer as to its specific character was the fact that the germs became agglutinated when added to the serum of a patient who had recent'y suffered with the disease. When a patient is suspected of having typhoid fever, the Grüber-Widal serum reaction is relied upon as a final diagnostic test, namely, the absence or presence of agglutination of typhoid fever germs when added to the serum of the patient's blood.

ATTENUATION AND ANTAGONISM OF BACTERIA.

The germs of different diseases have been subjected to all kinds of tests and tried under all sorts of conditions in order to study their peculiarities. Many strange facts have been learned. One is that bacteria of great virulence can be rendered weak and comparatively harmless by breeding them under adverse conditions. Another curious fact is that certain germs have a viol nt antipathy for each other, and if placed in a culture media in the same test tube will devote all their energies to a conflict, and only after one has subdued the other, does growth commence. This conflict is however not of a physical nature but is carried on by subtile chemical substances called enzymes which are thrown out by the bacteria and which literally disintegrate the opposed germs. For example, if a rabbit is inoculated with the bacillus of anthrax alone he will always die, but if after inoculation with the germ of anthrax he is inoculated with the bacillus pyocyaneus he will not die and may entirely escape infection.

THEORY OF IMMUNITY AND PREDISPOSITION TO DISEASE.

It has been discovered that some people "catch" diseases easily; that others never take them at all—that some have a predisposition to disease while others possess immunity. This is explained by the fact that a person who has a tendency to acquire a given disease to which he is exposed, has blood and tissues of feeble resisting powers and which present favorable soil for the growth and development of germs. A person who does not readily contract a given disease is said to possess unfavorable soil for bacterial growth.

THEORIES OF PROTECTION.

One attack of many infectious disease, such as small-pox, scarlet fever, etc., prevents a subsequent development of the same disease. This was formerly (1880) explained in two different ways; one the "abstraction" theory and the other the "retention" theory. According to the abstraction theory, the invasion of the system by a certain species of bacteria is attended by the removal of certain food products from the tissues necessary for the life of that special organism. This foodstuff is not replaced and hence the same breed of bacteria cannot again maintain an existence in the individual. The second, or retention theory, is based on the belief that recovery from an attack of infectious disease is due to the formation of bacterial products which are inimical to the further development of the bacteria and that an excess of these products remains and is retained in the system, and prevents a second occurrence of the same disease.

METSCHNIKOFF'S THEORY OF PHAGOCYTOSIS (1884).

Metchnikoff, the modest pupil of Pasteur, while practically an exile from Russia, offered a simple and plausible theory of normal resistance to infection and of natural immunity so often possessed by individuals to certain diseases. Metschnikoff observed in his study of lower life that certain animal organisms ingested and destroyed certain yeast fungi with which they came in contact. On investigation, he finally proved that in the human being the leucocyte or white blood cell possessed similar power, namely, that it ingested and destroyed micro-organisms, and he gave to this power the name of phagocytosis and called the leucocyte a phagocyte. In other words, Metschnikoff claims that the leucocyte exercises the function of a police patrol, and when it meets a germ it will arrest and imprison it. Sometimes a germ offers little or no resistance and it is easily captured and removed. Again the germ proves pugnacious and a terrific struggle ensues. Upon the issue of the combat between the leucocyte and the germ, depends the health or life of the individual.

ALEXIN THEORY OF BUCHNER (1890).

Opposed to the cellular theory of Metschnikoff is the alexin theory of Buchner. Buchner claimed that the bactericidal action of the blood was not necessarily due to phagocytosis and that the serum entirely free from cellular elements possessed a bactericidal action equal to that of the blood with all its constituent parts. He attributed the resistance of animals to infection to this property of the serum, which he believed to be due to a substance which he called alexin.

SIDE-CHAIN THEORY OF EHRLICH (1897).

Harmonizing the cellular theory of Metschnikoff and the alexin theory of Buchner is the side-chain theory of Ehrlich. It was first advanced to explain the formation of antitoxin and its mode of action and has recently been elaborated so that it not only furnishes the most scientific theory of immunity in all its phases, but has also given a rational basis for the practical use of opsonins and amboceptors.

Ehrlich's theory consists essentially of the three following tenets:

First, antitoxins counteract toxins by entering into chemical union with them. Second, toxins, in injuring a cell, combine chemically with specific groups of atoms called receptors. Third, antitoxins are merely these cell receptors which have been produced to excess by the cells and cast off into the serum.

Stripping the theory as far as possible of the technical terms that have been coined by its originator, the following is a brief statement of its leading features. Germs, during their growth in the body, produce poisons called toxins. Different germs produce different toxins. Each toxin has certain characteristics and produces a definite set of symptoms. It has long been recognized that in some indefinite way nature resisted the action of toxins and it was finally claimed that this was done by the formation of antitoxins. Before the publication of Ehrlich's theory all that could be stated was that antitoxins were produced as a result of the reactionary effort of the system to defend itself against infection. No effort was made to explain the origin of antitoxins, the nature of antitoxins, or how antitoxins restored health or conferred immunity. Ehrlich noted that when toxin and antitoxin were combined in proper proportions in a test tube that a non-toxic substance resulted. On heating the fluid, however, he found that it again became toxic. This seemed to indicate that at first a union had taken place between the toxin and the anti-toxin in which neither was destroyed, but that on heating the combination, the bond of union was broken and the two substances liberated. What was the character of the link that could be coupled and uncoupled? In attempting to solve this problem, Ehrlich studied the metabolism of the normal cells of the body, and soon reached the conclusion that it was necessary to assume that the cell constituents must enter into chemical combination with food substances in order that the latter might be made available for the use of the cell. He therefore claimed that cells were made up of certain atom groups of unknown chemical nature which made possible the binding of foodstuffs, and to these groups he gave the name of "receptors" from the fact that it was through them that substances were received into the cell.

He then reached the conclusion that just as it was necessary for a poison to get into an animal before it could exert its effect, so it was necessary for a toxin to gain entrance into a cell before the latter could be affected. The only way a toxin could link itself to the cell was by means of a group of atoms which corresponded to the cell receptors. These atom groups he called haptophores, and the group which possessed the toxic property of the toxin he called the toxophore. Having described Ehrlich's theory of the method by which a toxin gains entrance to a tissue cell, we will next consider the production of antitoxin, for the damage inflicted by the toxin is a necessary antecedent of the ultimate reaction that results in protection. When a toxin unites with a cell, there is as a necessary consequence, the destructive action of the toxin on the vital activity of the cell. The more molecules of toxin attached to the cell, the greater the injury to the cell and the greater the number of receptors "bound." If the amount of toxin is not sufficient to destroy the cell, then there is resistance, reaction, or response to injury by the cell. Regeneration demonstrates that tissues have a tendency to reproduce, not only to the extent of repairing the injury but even to the point of increasing the original number of cells. As an example may be cited the excess of connective tissue cells in a cicatrix. When a non-fatal amount of toxin unites with the receptors, a cell defect or injury is created. For practical purposes the cell may be said to have lost just so many receptors. This loss stimulates the vital activities of the cell with the result that new receptors, identical with those "bound," are replaced. Receptors are frequently reproduced in excess of the number injured, and the excess may be so great that the cell may be overstocked with them, and many may be cast off and reach the general circulation. These cast-off receptors, or side chains, still retain their power of uniting with the toxin and constitute the antitoxin. Hence the truth of Behring's statement: "The receptor when attached to the cell is the agent through which the latter is attacked, but when cast off from the cell is its protector."

ELABORATION OF EHRLICH'S THEORY.

The result of experimental work has led to the expansion of Ehrlich's Theory so that it not only explains the production of antitoxin, but also accounts for phagocytosis and bacteriolysis as well. This has necessitated the assumption that the cells of the body have three different classes of receptors:

Receptors of the first class, consisting of a single haptophore group. In this class are included the antitoxins which combine with and neutralize the toxins.

Receptors of the second class, consisting of a single haptophore group and an additional group called the zymophore. In this class are included the opsonins, which prepare bacteria for phagocytosis.

Receptors of the third class, consisting of two haptophore groups, one for union with a complementary or activating group called the complement, and one for union with a foreign cell. In this class we include the amboceptors which combine with alexins to form bacteriolysins.

OPSONINS.

Opsonins are receptors of the second-class which, acting upon bacteria, sensitize them for phagocytosis; hence the name "opsonins" from *opsono*—I cater to. These substances are made up of a haptophore group by which they attach themselves to the bacterium, and a zymophore group which, acting like a ferment, completes sensitization of the bacterium. Opsonins occur normally in blood serum as a part of nature's defense against infection. The infecting bacterium is exposed to their action as soon as it comes in contact with the blood, and in a short time is rendered attractive to, and assimilable by, the leucocytes, which immediately incorporate them.

Recently the study of opsonins has become of great practical importance, because it has been found possible to actually measure their relative amounts in the blood serum, and in certain infections to increase them to such an extent as to sensitize the bacteria so that they are all ingested by the leucocytes, and thus an otherwise hopeless disease cured. The way in which the relative amount of opsonin in a given case is determined is as follows: The serum of the blood to be tested and the serum of normal blood are mixed separately with equal volumes of a suspension of a pure culture of a given bacterium and a suspension of leucocytes. These two mixtures are drawn into separate glass tubes, sealed and placed in an incubator for fifteen minutes. At the end of this time they are withdrawn and stained preparations made and examined. The average number of bacteria ingested by each leucocyte in the mixture containing the serum tested is divided by the average number of bacteria ingested by each leucocyte in the mixture containing the normal serum. This quotient is known as the opsonic index of the blood tested and indicates the relative amount of opsonin present.

The way in which the production of opsonins may be increased in a given case is by the injection of "vaccines" consisting of a sterilized culture of the infecting organism. A suspension of the culture is first made in physiologic salt solution, and after sterilization for half an hour at 75° C. and determining the number of bacteria per cubic centimeter, it is ready for inoculation. From two to seven billion bacteria are given at a dose. After the inoculation, the opsonic index should be estimated daily to determine the amount of the next dose and the time at which it should be given. The first day after the administration there is a marked diminution in the opsonic index called the negative phase. This is followed by a gradual rise until it reaches far above normal, and this is called the positive phase. Then there is a gradual fall. This is the proper time for the next dose. When this is given the same changes will be noted as before, except that both the initial fall and the subsequent rise will be more marked. The treatment is applicable to chronic infections in which the resistance of the patient is at a low ebb. The diseases in which this treatment has been successful are chronic infections with the staphylococcus, gonococcus, pneumococcus and colon bacillus; also tuberculous infections of the joints, bones, bladder and peritoneum. It is most useful when supplemented to the usual surgical treatment of these affections and especially when ample drainage is secured.

AMBOCEPTORS.

Bacteriolytic amboceptors are receptors of the third order which, linking a ferment-like substance normally present in the blood with the infecting bacteria, causes their degeneration. These substances supply nature's defense, especially against those bacteria which do not excrete soluble toxins and therefore cannot stimulate the cells to the production of antitoxin, e. g., cholera, typhoid fever and plague. That this destruction of bacteria is caused by the combined action of two substances is shown as follows: If from an animal immunized against cholera by injections of killed cultures, some of its serum is withdrawn and mixed with a living culture of cholera spirilla and examined in a hanging drop preparation, the bacteria will be seen to become completely disintegrated in from twenty to thirty minutes. If the same experiment is again performed with the same serum which has been heated to 60° C., no destruction of the bacterium will occur, showing that the chemically active part of the serum has been destroyed.

Now if a trace of the unheated serum, too small to produce any bacteriolytic action alone, be added to the heated serum and the experiment again performed, the bacteria will be dissolved as before, showing that there are two different substances present, one which is chemically active and easily destroyed by heat, the other which brings the chemically active part into chemical relation with the bacteria and is heat resistant. The chemically active part is identical with the alexin of Buchner and is called the complement because it completes the amboceptor, making it active. The link which unites the complement to the bacterium and enables it to act, is called the amboceptor because it is receptive at both ends. The end which receives the complement is called the complementophilous haptophore, and the end which unites with the bacterial cell is called the cytophilous haptophore.

Used therapeutically as a curative agent, antibacterial sera containing specific amboceptors are extremely dangerous, as by disintegration of the bacteria present in the body, they set free their endotoxins and suddenly overwhelm the patient at the same time the bacteria are killed. As a prophylactic measure, however, they are found very effective in cholera, plague and typhoid, especially if used in conjunction with injection of dead bacteria. In this way, the patient first is rendered immune during the negative phase of opsonization, and later, if infection should occur, the leucocytes readily deal with the sensitized organisms before they gain a foothold.

The order in which these three serum defenses of the body are brought into action in an actual fight against infection is as follows: First, the bacteriolysins or alexins disintegrate and dissolve the bacteria before they have accumulated in such numbers as to set free an overwhelming amount of endotoxin by their dissolution. Next the opsonins prepare the bacteria for phagocytosis. Next, if the bacterium resists extermination and produces a soluble toxin which is thrown into the circulation, antitoxin is formed by the cells to neutralize it.

LECTURE V.

THE BLOOD—COMPOSITION AND FUNCTION—DESCRIPTION OF BLOOD PLASMA AND BLOOD CORPUSCLES—REGENERATION OF BLOOD AFTER SURGICAL OPERATION—DIFFERENTIATION BETWEEN SHOCK AND HEMORRHAGE—BLOOD CHANGES IN SUPPURATION, TUBERCULOSIS, LEUKEMIA, PYEMIA AND HEMOPHILIA.

Blood is a red, viscid fluid, having a specific gravity of 1060, an alkaline reaction, and constitutes about one-fourteenth of the entire body weight. Its distribution is about one-fourth to the lungs, heart and large vessels, one-fourth to the skeletal muscles, one-fourth to the liver, and one-fourth to the other organs of the body. The color of arterial blood is bright red, and of venous blood, bluish purple; the difference being due to the relative amount of oxygen and carbon dioxide present in each. Arterial blood contains more extractives, more salts, more sugar, less urea, and is warmer than venous blood.

The functions of the blood may be classified under four heads:

1. To convey nutrition;
2. To remove waste products;
3. To carry oxygen;
4. To distribute heat.

Blood is composed of innumerable microscopical bodies sus pended in a clear yellow fluid; the solid particles or corpuscles constituting 44 per cent and the fluid or plasma 56 per cent. The corpuscles have a specific gravity of 1088 and the plasma a specific gravity of 1031. The corpuscles are, therefore, slightly heavier than the fluid in which they are suspended, and if blood is allowed to stand in a beaker it will separate into two strata, the corpuscles at the bottom and the plasma at the top. An examination of blood-corpuscles will show that there are three distinct varieties.

Hence a systematic study of the blood must embrace: first, the plasma; second, each of the three corpuscular elements.

I. THE FLUID ELEMENT.

Plasma or liquor sanguinis is a clear, yellowish fluid, alkaline in reaction and is composed of 90 per cent of water, and contains gases, mineral salts, fats, nitrogenous bodies and carbohydrates in solution. It also contains a ferment that causes coagulation by the production of fibrin. As the chief interest of the pathologist centers in the corpuscles and not in plasma, the subject will be left with merely the repetition of the following formula, familiar to students of physiology:

Living blood = plasma + corpuscles.
Dead blood = clot + serum.
Clot = corpuscles + fibrin.
Serum = plasma − fibrin (− ogen).
Plasma = Serum + fibrin (− ogen).

II. THE CORPUSCULAR ELEMENT.

1. *The Red Blood Cell*, or erythrocyte, is a round, bi-concave disk without a nucleus; when viewed singly it is yellow, but when seen *en masse* it is red. In size, it is about $\frac{1}{3200}$ of an inch in diameter. It is composed of an elastic frame-work or stroma containing hemoglobin. It has little or no power to alter its shape, but owing to its elasticity it can be forced through a capillary smaller than its own diameter, and afterwards will resume its original form. The life of a red blood cell cannot be long, as bile and urinary pigments are the results of its disintegration and the liberation of hemoglobin. The red blood cells of the fetus are at first nucleated but at the end of the third month only one-sixth are nucleated, and at birth no nucleated cells are found. In post-natal life, red blood cells are derived from the red marrow of bone. At one time, the spleen was thought to be the place where they were destroyed, but this theory has been abandoned owing to the observation that the removal of the spleen does not interfere with their destruction. The liver is now supposed to be

their graveyard. Hemoglobin constitutes 40 per cent by weight of the red blood cell. This is a very complex crystalline coloring agent containing iron. It can carry a molecule of oxygen linked to it in a way to be easily dissociated. Hemoglobin gives to the red blood cell its power to convey oxygen. The total number of red blood cells in an adult is estimated at approximately 25,000,000,000,000. The length of these cells placed edge to edge would be 109,370 miles. The total surface of the cells would be equivalent to the area of one and one-half acres. While the above facts are impressive and serve to emphasize the importance of the red blood cells, it is more practical to consider them in a more tangible form. Red blood cells are normally 500 times more numerous than white blood cells. On an average there are 5,000-000 blood cells in a cubic millimeter of blood in the male and 4,500,000 in the female, although this varies in health with nutrition, age, elevation, etc. In disease there are many abnormalities in number, shape, color, amount of hemoglobin, etc. Sometimes nucleated types are seen.

2. *White Blood Cells*, or leucocytes, are round nucleated masses of protoplasm having no investing membrane or cell wall, and are about $\frac{1}{2500}$ of an inch in diameter. White blood cells are consequently larger than the red blood cells, and as has already been stated are found in health numerically in the proportion of only 1 to 500 of the latter. White blood cells occur normally in the blood in three different varieties, probably representing three stages of development.

1. Small mononuclear leucocytes are characterized by scant protoplasm, relatively large nucleus, and contain no granules.
2. Large mononuclear leucocytes contain a larger amount of protoplasm, and no granules.
3. Polymorpho-nuclear leucocytes contain granules. (*a*) Neutrophilic granules stain with neutral dyes. (*b*) Eosinophilic granules stain with acid dyes.

White blood cells contain fibrin ferment and when undergoing disintegration, aid in the production of fibrin by which hemorrhage is arrested and wounds are agglutinated. In addition, their bodies furnish food in an assimilable form for the other cells.

The most interesting properties of the leucocyte, however, are its powers of ameboid movement and phagocytosis, both dependent on its ability to change its shape. Ameboid movement is accomplished by throwing out a projection or arm and then allowing the body of the cell to flow into it. By this means the organism has an intrinsic power of locomotion that enables it to travel even in opposition to the flow of a current of fluid. The second property, namely, that of phagocytosis, is the ability the organism possesses of taking foreign bodies into its interior and there digesting and destroying them. A leucocyte is, therefore, sometimes a tramp, sometimes a scavenger and sometimes a warrior. White blood cells are found in the blood at an early period of embryonal life. The first are probably ameboid cells of mesoblastic origin. In adult life they are manufactured in the lymph nodes. When they first enter the circulation, they are mononuclear cells without ameboid movement. Later, they become large and the nucleus divides, giving to the polymorpho-nuclear cell ameboid movement. On an average there are normally about 10,000 white blood cells to the cubic millimeter in men and 9000 to the cubic millimeter in women. The number decreases during fasting, old age, the administration of certain drugs and under many other circumstances. The number increases after digestion, hemorrhage, pregnancy, in diseases in which suppuration occurs, and in leucocythemia.

3. *The Third Blood Cells*, or platelets, are small, circular bodies homogeneous in structure, smaller than the red blood cell, and number about 400,000 per cubic millimeter. In drawn blood they disintegrate quickly and for this reason they were not discovered until recently. Their origin, structure and function are not clearly known, but they are composed largely of globulin and play an important part in coagulation.

Having reviewed the chemical and histological composition of the blood and recalled some of its physiological functions, the student is now in a position to appreciate the pathological changes which occur in many diseases, and recognize the significance of departures from normal, which may be noted by examinations made by methods taught in other departments. Urinalysis is now on a firm foundation and no diagnostician would fail to avail himself of the knowledge it affords without subjecting himself to criticism even by the laity. The examination of the stomach contents after a test meal is already a routine method in the study of gastric disorders. The day is not far distant when a blood examination will be a constant practice before a surgical operation, to determine the safety of the expedient, and after the operation to measure the recuperative powers of the patient.

BLOOD REGENERATION AFTER AN OPERATION.

The time required for full restoration of the blood after an operation, depends on the amount of blood lost, the age and state of nutrition of the patient, the existence of other diseases and finally the treatment instituted. A loss of less than 1 per cent of the total amount of blood is usually made up in from two to five days; from 1 per cent to 3 per cent is made up in from five to fourteen days; from 3 per cent to 4 per cent is made up in from fourteen to thirty days. It has been observed that blood regeneration is slow after an operation for malignant disease, and that it never reaches as high a point as it was before the operation. Mikulicz makes it a rule never to operate on a patient whose hemoglobin is less than 30 per cent. Surgeons should have the percentage of hemoglobin estimated in all doubtful cases and postpone operation when it is below the minimum fixed by Mikulicz unless the case be an urgent one.

DIFFERENTIAL DIAGNOSIS BETWEEN SHOCK AND HEMORRHAGE.

In many accident cases, one of the first questions presented, is whether to operate at once or wait for reaction. Is the condition of the patient due to shock or to hemorrhage? Will the patient improve or grow worse under the expectant treatment? An examination of the blood will often aid in settling the question. If the patient has not a history of previous anemia and the count of the red blood cells shows 3,500,000 or less to the cubic millimeter, the symptoms are probably due to hemorrhage. If successive blood counts show progressive diminution of the number of the red blood cells the bleeding is probably still going on. Internal or concealed hemorrhage, such as occurs in ruptured extra uterine pregnancy, ruptured aneurism, or slipped ligatures after abdominal section, can usually be diagnosed by a blood count. It must be remembered, however, that immediately after hemorrhage, the count may be normal, since only the amount and not the quality of the blood has been affected. Within a few hours, the absorption of fluid from the tissues and the restoration of the normal bulk of blood enables the "count" to show the amount of anemia present.

DIAGNOSIS OF DEEP-SEATED SUPPURATION.

Pent-up pus, especially if the inflammatory process be acute, almost always manifests itself by the production of more or less marked leucocytosis, or an increase in the actual and relative number of the polymorpho-nuclear leucocytes. The degree of leucocytosis is not dependent upon the amount of pus. A few drops of pus frequently raises the count as much as many ounces. A progressively increasing leucocytosis points to a spreading suppurative process. Frequently, timely operations are done for suppurative appendicitis or osteomyelitis when the only indication of an advance of the disease is an increase in the number of white blood cells found upon successive examinations. Occasionally leucocytosis is absent, despite the presence of pus. There are several explanations offered for this, but none are entirely satisfactory. All that we can say, is, that marked leucocytosis indicates pus, but that absence of leucocytosis does not positively exclude its existence. In other words, leucocytosis makes a positive, but not always a negative diagnosis of deep-seated suppuration. A white blood count of from 14,000 to 30,000 to the cubic millimeter, indicates a mild suppurative process; over 30,000 to the cubic millimeter a process of great intensity. Usually after an abscess is opened and exit is given for the pus, the leucocyte count rapidly falls to normal. The leucocyte count will frequently rise after probing or packing the wound.

BLOOD CHANGES IN CERTAIN DISEASES.

1. *Tuberculosis.* Pure tubercular infection does not produce leucocytosis. If the blood count in that disease shows an increase of white cells it indicates a mixed infection with pus germs.

2. *Malignant Diseases.* Malignant diseases, such as carcinoma or sarcoma, do not cause leucocytosis unless secondary suppuration occurs as a complication. In the later stages of a malignant disease there is marked anemia and occasionally there is nucleation or deformation of the red blood cells.

3. *Leukemia.* The diagnosis of leukemia can be made with absolute certainty by an examination of the blood. In leukemia there is a large increase in the number of the white blood cells; but it is different from the increase that occurs in suppurative diseases; the difference consisting not in the number of leucocytes but in the variety of leucocytes. In leukemia, the leucocytes are principally of the mononuclear type, while in leucocytosis from suppuration the leucocytes are of the polymorpho-nuclear type.

4. *Pyemia and Septicemia.* Frequently the examination of the blood in septic cases will give information of great diagnostic, prognostic and therapeutic value. Blood is taken from one of the veins at the elbow under aseptic precautions and subjected to a bacteriological test. Sometimes in severe cases, no culture may be grown, but often the pneumococci, gonococci, staphylococci, streptococci or other micro-organisms may be demonstrated. Antistreptococcic serum would in some cases be a useful remedy if the infection was streptococcic. Its use would be of no avail if other forms of microbic infection were found.

5. *Hemophilia.* There are certain conditions of which hemophilia is a type, in which there is marked retardation of the time taken for coagulation. Clotting of blood, nature's method to effect primary hemostasis, normally requires only three or four minutes. In exceptional instances, this time may be increased to one or two hours. In suspected cases observation of the "coagulation time" carried out systematically may often save life by giving warning of the danger of uncontrollable hemorrhage after an operation.

LECTURE VI.

PHYSIOLOGICAL AND SURGICAL REGENERATION—PROCESS OF REPAIR IN WOUNDS—GRANULATION, VASCULARIZATION, CICATRIZATION AND EPIDERMIZATION—UNION BY PRIMARY AND UNION BY SECONDARY INTENTION.

Injuries to the body, whether from accident or disease, are repaired by the same process that effects the normal restoration of cells during the growth and development of the body. Therefore, before considering the method by which wounds heal, or "surgical regenération," it will be well to review the method by which the normal waste of the body is restored, or "physiological regeneration." The two processes are identical and the different names applied to them are employed not to indicate a difference in nature but in degree.

PHYSIOLOGICAL REGENERATION.

The body is composed of cells. The life of a cell is not as long as the life of the body. Some cells are more hardy than others, but all cells die after the completion of their natural life, or are destroyed earlier from excessive functional activity. In health there must be some provision for the reproduction of cells to replace those that die; else the body would perish. This need is met by what has been termed physiological regeneration, which consists in the ability of pre-existing cells to proliferate and form new cells. In this process, the law of the legitimate succession of cells is followed, and like cells produce like cells. Thus a muscle cell begets a muscle cell, a nerve cell begets a nerve cell and a bone cell begets a bone cell. During early life, cell reproduction is in excess of cell destruction and there is growth of the body. During middle life, cell reproduction about equals cell destruction and there is a balance of weight. During old age cell reproduction is usually less than cell destruction, and there is senile atrophy of tissue. The cell in an organ which proliferates to form new cells, is usually called the *formative cell* of that organ. In connective tissue there are two distinct sets of cells, the fixed cell and the wandering cell. It has been clearly shown that the fixed cell of connective tissue is the formative cell. This has led some pathologists to speak of the fixed tissue cell as the formative cell, and frequently to speak of the formative cell of other tissues as the fixed tissue cell of that tissue. This practice is confusing, and should be discontinued. Senn dignifies the formative cells of different structures by different names, calling the formative cell of connective tissue a *fibroblast;* of bone an *osteoblast;* of nerves a *neuroblast;* of muscle a *sarcoblast;* of blood vessels an *angioblast,* etc.

SURGICAL REGENERATION.

All wounds, whatever the anatomical tissue involved, heal by the production of new cells which result from the proliferation of pre-existing cells. The formative cells at the site of injury are stimulated to unusual activity, and multiplying rapidly, form an immense number of new cells. These cells constitute what is commonly spoken of as granulation tissue. At first the new cells are embryonal and lack the characteristics of their parents; but as they mature, they develop into cells identical with those of the tissue from which they had origin. Thus in the granulations covering the surface of a recent wound, it is impossible at first to distinguish the embryonal cells resulting from different tissues, but later, when they mature or undergo cicatrization, the cells originating from connective tissue become converted into connective tissue, those originating from bone will be converted into bone, and those originating from muscle will become converted into muscle. It is a fact that the formative cells of connective tissue have a very much higher vegetative capacity, or power of proliferation, than the formative cells of any other structures; and as connective tissue is found everywhere in the body, the bulk of the granulation or embryonal cells produced in any wound will have a connective tissue origin, and the development of these cells results in the formation of a fibrous cicatrix.

At one time there was much controversy over the part played in the healing of a wound by the leucocyte or white blood cell. Leucocytes are invariably present among the embryonal cells, but it has been conclusively proven that they take no permanent part in tissue production. They do not undergo proliferation, but disintegration, and their function is chiefly to produce fibrin for the temporary agglutination of opposed surfaces, and to furnish in an assimilable shape, food for the procreating formative cells.

HEALING OF WOUNDS.

The details of the process of repair in a wound, can best be studied under the headings, granulation, vascularization, cicatrization, and epidermization. We will take them up in order.

1. *Granulation.* This is the process by which new cells are formed to replace tissue lost by accident or disease. All wounds heal by the production of new cells or granulation tissue. If the surfaces of the wound are clean cut and held in close apposition, one to the other, the amount of new material necessary to effect vital union is little, the time required for healing is short and the resulting cicatrix is small. If the surfaces of the wound are not brought into close relationship, the amount of new material necessary to fill in the gap is large, the time necessary for union to occur is long and the resulting cicatrix is large. The process of granulation, however, is exactly the same in each; the only difference being the number of new cells formed and the length of time necessary to do so. Healthy granulations are small, firm and pink, and their surface is moistened with a viscid colorless fluid. If infection occurs, they become pale and flabby and their surface may be covered with a membrane or bathed in a purulent discharge. The layer of granulations on the surface of a wound becomes about one-sixteenth of an inch in thickness and then proliferation and the formation of new cells will be arrested unless an additional blood supply is furnished.

2. *Vascularization.* This is the process by which new blood-vessels are formed to nourish the growing granulation cells. At first an increased supply of blood is furnished to the part by the plugging of the cut ends of the capillaries with thrombi and their dilatation from intravascular pressure. Later this is not sufficient and new vessels are formed to convey nourishment to the granulation cells. As Senn puts it, vessel formation and tissue proliferation must be initiated simultaneously and keep pace with each other until the necessary amount of granulation tissue has been produced. The new blood vessels, formed by the process of vascularization, come from the nearest pre-existing blood vessels. A bud appears on the wall of a capillary and increases in size until it is a triangular mass and finally it is transformed into a finger-like projection. It becomes excavated at its base and blood enters from the vessel to which it is attached. When two such formations are contiguous, they join each other by the inosculation of their tips and a capillary loop results. This loop, uniting with other loops, permeates the new cells and conveys nutrition, which enables them to continue their proliferation. Each loop, as it projects toward the surface, is covered with embryonal cells and gives a velvety appearance to the layer of granulations. These new vessels are but temporary in existence and are obliterated with the final healing of the wound.

3. *Cicatrization.* This is the process by which embryonal cells or granulation tissue, develop into mature cells endowed with the characteristics of their parents—in other words, the transformation of the embryonal cells from fibroblasts into connective tissue; the embryonal cells from sarcoblasts into muscular tissue; the embryonal cells from neuroblasts into nerve tissue, etc. If as is rarely the case, the formative cells of the various tissues have vegetative or reproductive capacity sufficient to produce enough embryonal cells to repair the defect produced in their respective structures, then upon the completion of cicatrization there will be complete anatomical and physiological restoration of the injured part. If, however, as is usually the case, nearly all of the embryonal cells which constitute the granulation tissue originate from the fibroblasts, then on completion of cicatrization

there will be substitution in the cicatrix of connective tissue for the normal structure of the part, or a condition known as *metaplasia.* The fact that almost all cicatrices are composed largely of connective tissue, together with the well known contractility of this element, will explain scar contraction. The contraction of connective tissue in the healing of a wound is useful inasmuch as it draws the divided surfaces nearer together, lessens the external evidence of injury and obliterates by constriction the newly formed blood vessels. This is seen in the everyday observation of a scar becoming smaller and whiter with time. The contraction, however, sometimes goes so far as to prove a source of danger, since it may result in deformity of limb if the region of a joint is involved, may cause pain by pinching a nerve, or may produce stricture by diminishing the lumen of some duct or canal.

4. *Epidermization.* This is the process by which new epithelial cells are formed to cover the granulation area. An external or open wound cannot be said to have completely healed until new skin or mucous membrane forms over its surface. As skin and mucous membrane are composed of epithelial cells, the restoration of the loss of their continuity must be by the proliferation of pre-existing epithelial cells. The nearest formative cells of this type are at the margins of the wound, and it is from this source that the new material is produced. In the process of epidermization new cells appear at the periphery of the wound and creep in to meet near the center. At first these cells do not appear to be attached to the underlying granulations, but merely lie upon them. Later they affect organic union. Occasionally in granulating areas due to a burn, islands of epithelial cells will appear which obviously have not originated from the edges of the wound. These are due in many cases to epithelial cells of some hair follicle which, owing to their location, have escaped destruction and act as independent centers of epidermization.

CLASSIFICATION OF HEALING WOUNDS.

Before the introduction of aseptic and antiseptic methods in surgery, practically all wounds suppurated, and the old authors, seeing inflammation commonly coincident with healing, believed it to be an essential part of the process. It is hoped that the student will have already appreciated the erroneousness of this theory, as it has been the endeavor to impress the fact that regeneration as it occurs in the healing of a wound is but an augmentation of a natural process which is always operative in the body to restore the normal physiological waste of the tissues. The old authors classified healing of wounds under three heads: first, direct or immediate union, or healing without the interposition of new material, which is an impossibility; second, healing by plastic inflammation, a term which has no place in modern pathology; third, healing by suppurative inflammation, which on its face is an absurdity. The present classification of wound healing is simple and divides the process into: healing, first, by primary intention, when the wound is aseptic and regeneration occurs without inflammation; and, second, by secondary intention, when the wound is infected and regeneration is delayed by inflammation.

1. *Union by Primary Intention.* In union by primary intention the patient has practically no fever and the wound heals under a single dressing without the local symptoms of inflammation. There is no discharge save the escape of a little blood serum and none of the granulation cells are destroyed, but all go to accomplish the end for which they were produced; hence repair is effected with a minimum tax on the system.

2. *Union by Secondary Intention.* In union by secondary intention, the patient has fever and the attendant constitutional disturbances. The wound is painful, hot, red and swollen. The stitches cut into the skin and the margins gape and become everted. Pus forms, granulation cells are destroyed and there is a discharge which saturates and necessitates the changing of dressings. Healing is delayed until the infection runs its course or is eliminated by antiseptic measures. Owing to the destruction of embryonal cells, these have to be reformed over and over again, thus putting a tax on the patient's system which, together with the fever, pain and long confinement, often causes great debility.

LECTURE VII.

VEGETATIVE CAPACITY OF TISSUE—REPAIR OF TENDONS, WITH DESCRIPTION OF TENORRHAPHY AND TENOPLASTY—REPAIR OF MUSCLES—MUSCLE SUTURING—REPAIR OF SURFACE EPITHELIUM, WITH DETAILS OF THREE METHODS OF SKIN GRAFTING.

The different tissues of the body vary in their ability to effect repair after injury. In other words, the formative cells of some tissues have a greater power of proliferation than the formative cells of other tissues. On this fact is based the estimate of a tissue's vegetative capacity. It is important for the surgeon to know the probability of repair after accidental injury, and so to plan his incision in operative work with reference to the ability of the tissues to heal promptly and with a satisfactory cicatrix. The regeneration of special tissues is therefore a subject of practical interest.

The vegetative capacity of a tissue is dependent largely upon two factors, first the richness or paucity of its blood supply, and second the high or low development of the cell which enters into its formation. Other things being equal, the more bountiful the blood supply, the higher the vegetative capacity, for while the cellular elements of the blood never take an active or permanent part in tissue production, the blood plays an important rôle in providing fibrin by which the surfaces of the wound are temporarily agglutinated and in supplying nourishment to the formative cells whose multiplication results in the final restoration of the part. Thus, for instance, owing to the more abundant blood supply, wounds of the fingers heal more quickly than wounds of the forearm, and wounds on the face more quickly than wounds on the neck. Again, tissues composed of cells of low development, possess a higher vegetative capacity than tissues formed of cells more complex in structure. As is well known to students of histology, some tissues are composed of cells so simple in form as to be almost elemental, while other tissues are composed of cells exceedingly complex. It is natural to infer that cells of simple structure will be more rapidly reproduced than cells of high development, and this is true. Wounds of the skin or fascia heal much more readily than wounds of nerves or of muscles. It is a practical fact that under favorable circumstances injuries to surface epithelium and all connective tissues, such as fascia, tendons and bone, undergo perfect repair, while injuries to the brain, nerve trunks, striated and unstriated muscle tissue and glandular structure are usually restored by metaplasia, or the substitution of connective tissue cells for those of the original structure.

REPAIR OF TENDONS.

Tendons are composed of white fibrous connective tissue and are designed to economize space and afford additional strength and leverage for the attachment of muscles. Tendons, while much smaller than their respective muscles, are the stronger of the two structures. Tendons are encased in a fibrous sheath and move without friction owing to lubrication with synovial fluid. If a tendon is cut, there is temporary or permanent loss of the function of the muscle with which it is connected. Tendons have high vegetative capacity and frequently there will be restoration of continuity when the divided ends are separated as much as one or even two inches. When a tendon is cut, the divided ends retract in their sheath and hemorrhage occurs sufficient to fill the gap with a cylindrical clot. The formative cells or fibroblasts on the inner wall of the tendon sheath and on the cut end of the tendon, proliferate and form embryonal cells or granulation tissue which infiltrates and permeates the blood clot. These cells undergo vascularization and later cicatrization. The blood clot is ultimately replaced by white fibrous tissue.

TENORRHAPHY.

Primary tenorrhaphy consists in the suturing of a tendon soon after it is divided. It is performed by exposing the retracted ends of the tendon and uniting them by means of chromicized catgut. The part should then be placed in the position calculated to give least tension on the sutures and immoblized. Secondary tenorrhaphy consists in the suturing of a tendon some weeks or months after its division. Owing to the contraction that has usually taken place, the operation commonly necessitates tenoplasty or the resort to expedients to lengthen the tendon. The part should be rendered bloodless by means of an Esmarch's bandage, and the ends of the tendon sought for and exposed. If they can be brought together without undue tension they should be revivified and sutured. If such is not practicable, a flap should be cut from each end and the flaps united to each other. If a tendon is not severed, but simply contracted, it may be lengthened by splitting it lengthwise and cutting through each half on opposite sides and then suturing the resulting extremities.

REPAIR OF MUSCLES.

Muscles are of two types: The unstriated and the striated; the first not under control of the will and doing the work of involuntary organic life; the second acting in obedience to volition and performing voluntary functions. It is unnecessary to go into the histological structure of the two cells. For present purposes, it will suffice to say that the long, fusiform unstriated fibers are arranged in broad sheets and envelop the hollow viscera, such as the stomach and intestines, while the cylindrical striated fibers are gathered into bundles and form the skeletal or muscles of locomotion. A muscle being composed of cells of a high order of development, is a tissue of low vegetative capacity. In fact, for a long time it was believed to have no regenerative power but that injuries inflicted were repaired exclusively by the production of connective tissue and the formation of a fibrous cicatrix. More careful investigation has shown, however, that muscle tissue both striated and unstriated has a limited power of reproduction, and the formative cells demonstrated to exist, are termed sarcoblasts. When a muscle is divided, and the cut ends allowed to retract for a distance of one or two inches, the amount of new material necessary to bridge the gap, is too great to be supplied by the vegetative capacity of the structure. Repair is effected by metaplasia, or the substitution of connective tissue. If, however, the cut surfaces are brought together and maintained in apposition, the sarcoblasts proliferate and form new cells sufficient for repair. These cells undergo vascularization and cicatrization, and there is ultimate healing with anatomical and physiological restoration of the part. When a muscle is ruptured or divided, it is as much the duty of the surgeon to suture the divided ends as it is his duty to unite a tendon or reduce a fracture. An incision should be made if necessary; the surfaces of the muscle brought together by mattress suture of absorbable material, and the union made secure by separate stitches in the fascia. The part should then be placed in a position favorable to relaxation of the sutured muscles and immobilized by a suitable mechanical appliance.

REPAIR OF SURFACE EPITHELIA.

The skin and mucous membrane are formed of epithelial cells. Since the cells are simple in structure and the tissues bountifully supplied with blood, their vegetative capacity is high. Repair after injury, takes places by proliferation of the nearest formative cells and the production of new cells. The nearest cells are either in the margins of the wound or at the base of hair follicles, which in superficial injuries, such as a slight burn, often escape destruction. If the formation of epithelium be studied on a granulating surface, the new cells will be seen creeping in from the margins of the wound, and occasionally developing as islands from buried deposits of pre-existing epithelial tissue. The new cells are at first pale and resemble the "skin" of an egg, but later undergoing cicatrization become transformed into new skin or mucous membrane. If the area to be covered is small, repair is usually rapid and complete, but if it is large, repair often progresses to a certain point and then ceases. In the one case, the capacity of the formative cells is sufficient to meet the demands made on them; in the other, the amount of material required is more than they can produce. When the destruction of skin is so extensive that the normal reparative power is insufficient to cover the granulating area with epithelial cells, recourse must be made to skin grafting. It has long been known that bits of cuticle properly planted on fresh wounds or healthy granulating surfaces, would become adherent and grow. The application of this fact has enabled the surgeon to cause quick and certain healing of wounds which otherwise would be slow to close, or perhaps become converted into permanent ulcers.

SKIN GRAFTING.

Skin grafting, when practiced on newly made wounds, is called primary grafting. When practiced on granulating surfaces it is called secondary grafting. If the surface be a fresh one, care must be taken to perfectly arrest hemorrhage before applying the grafts; otherwise they will be detached by the bleeding. If the surface be an old one care must be taken to stop suppuration before applying the grafts; otherwise pus germs will devitalize them. Skin grafts may be obtained from the patient and then are called autografts; they may be secured from another person and then are called heterografts; or they may be obtained from an animal and then are called zoögrafts.

There are three recognized methods of skin grafting: Reverdin's, consisting in cutting small particles from the superficial layers of the skin with scissors and planting them at intervals over the surface to be covered; Thiersch's, consisting in cutting broad strips from the superficial layers of the skin with a razor and placing them so as to completely cover the wound area; and Wolfe's, consisting in the dissection of a piece of skin the entire thickness of the structure and fitting it to the defect to be remedied. After any of the methods described, the surface grafted may be left exposed to the air without any dressing or it may be covered with a lattice work of strips of rubber tissue over which is placed a pad of gauze wet with normal salt solution. The instruments required for skin grafting are so few, the operation itself so simple, and the results secured so immediate and satisfactory that the surgeon who does not avail himself of it in suitable cases does an injustice both to himself and to his patient.

Primary skin grafting should be employed after the removal of an epithelioma or other superficial growth, provided infection can be prevented, hemorrhage arrested and ligatures and sutures avoided. Secondary skin grafting should be employed when ligatures are used to arrest bleeding, or sutures are necessary to secure partial coaptation; where infection is likely to occur or already exists, or where the excavation is deep and a large amount of granulation tissue is necessary to fill it.

1. *Reverdin's method* should be employed when the area to be covered is small, and where the administration of a general anesthetic is contra-indicated. The surface to be grafted and the site from which the grafts are to be taken should both be properly prepared. The skin is then elevated into a cone by means of a sharp tenaculum and a small piece snipped from its superficial layer by means of a pair of curved scissors. The fragment is at once transferred to the area to be grafted and carefully planted on the granulations, care being taken to prevent the edges of the graft from curling inward, thus preventing apposition of raw surfaces. This is repeated until a sufficient number of grafts have been planted to thickly stud the bare area. The operation of cutting the grafts can be made painless by the use of chloride of ethyl spray. The method is very satisfactory, especially in weak nervous patients, where a more formidable operation would have had a bad effect. The space between the grafts is rapidly covered and the resulting scar is good.

2. *Thiersch's method* should be used when the surface to be covered is large, and when the patient is either under an anesthetic or when its administration will be compensated for by the more certain result and rapid recovery this method ensures. The grafts are obtained by making the skin tense and flat either manually or by special hooks, and cutting off the superficial layers by a "to-and-fro" sawing motion of a sharp razor. The larger the size of the grafts, the better will be the result. Usually they are an inch in width and four or five inches in length. Care should be taken to remove only the upper layer of the skin, other-

wise the wound inflicted may prove as difficult to cure as the wound the surgeon is endeavoring to cover. As the grafts are cut they are carefully placed on the area to be grafted, the edge of one graft overlapping that of the adjacent one. Thiersch's method of grafting is the one most frequently practiced and the one which gives the most brilliant results. The objections to it are that it necessitates the use of an anesthetic and the site from which the grafts are cut is painful and requires some days to heal.

3. *Wolfe's method* should only be employed in exceptional cases. The surface of the area to be grafted, should be thoroughly revivified and the margins made fresh and vertical. All bleeding should be completely arrested. The new skin to be used as a graft must be dissected from some other site. The entire thickness of the skin should be removed but with no subcutaneous fat. The outline of the incision should preferably be an ellipse so as to permit of closure of the defect by sutures. The skin removed, should be one-third larger than the defect to be covered, to allow for shrinkage. The graft after having been placed in its new position, may be retained by sutures or reliance placed on overlying dressings firmly applied. The method is uncertain in results but may sometimes be used with advantage.

In addition to the recognized methods of skin grafting just described occasional reference will be found to grafting wounds with the "skin of an egg," with the pellicle of a blister and with dry epidermal scales, such as scrapings from callosities or dandruff from the head. These expedients usually yield unsatisfactory results. The only reasonable sources from which to obtain vital epithelial tissues are the skin of the patient, autografts; the skin of another individual, heterografts; and the skin of a lower animal, zoögrafts.

1. *Autografts* are usually cut from the patient's thigh or shoulder. They furnish the material most likely to prove successful and should be employed except in cases where the patient's general condition is bad or where the area to be grafted is very extensive.

2. *Heterografts* are obtained from another individual, from amputated extremities or from fresh cadavers. They usually

grow well and should be employed when they can be secured from a satisfactory source. They entail the danger of infecting the patient with syphilis, and other diseases which must be carefully guarded against. The question of the necessity of the graft being of the same color as the skin of the patient on which they are planted is still unsettled. It is claimed that a negro's skin grafted on a white person will lose its pigment and that a white skin grafted on a negro will become pigmented.

3. *Zoögrafts* are obtained from one of the lower animals, the frog, chicken, pig, dog, cat, rabbit or guinea-pig being most commonly used. They do not grow as readily as grafts from the skin of a human being and they should not be employed when other sources of supply are available. Still there are certain conditions where they are not only useful but are the only means by which a patient can be cured.

LECTURE VIII.

REPAIR OF BLOOD VESSELS—FORMATION OF THROMBUS AND FINAL HEALING BY PRODUCTION OF NEW TISSUE—REPAIR OF NERVES—VEGETATIVE CAPACITY OF CENTRAL AND PERIPHERAL SYSTEM—NERVE SUTURING—REPAIR OF BONE—CALLUS AND ITS FORMATION—TREATMENT OF FRACTURES.

REPAIR OF BLOOD VESSELS.

Arteries and veins are formed of three coats, the internal, or tunica intima, composed of endothelial cells, the middle, or tunica media, composed of elastic and muscular tissue, and the external, or tunica adventitia, composed of fibrous tissue. The two inner coats are firmly united to each other, but are very easily separated from the external coat. If a ligature be tied tightly around a blood vessel, the external coat will not be divided, but the two inner coats will be cut circularly in the line of the ligature, and will retract. It is essential for the safety of the patient that repair after injury to blood vessels be rapid and complete, and fortunately nature has endowed these structures with high vegetative capacity. Healing occurs, here as elsewhere, by proliferation of the formative cells and the production of new tissue, which, undergoing vascularization and cicatrization, results in permanent repair of the injury. When a vessel is divided, the tunica intima and tunica media separate from the tunica adventitia and retract. Their edges curl inward, fibrin is deposited upon them, and a thrombus is formed, which arrests bleeding. The action of this plug of coagulated blood is temporary, however, and the formation of a permanent cicatrix must follow, else the patient will be in danger of a recurrence of hemorrhage. The old authors thought that the final healing of a blood vessel was accomplished by what they termed "organization of the thrombus," but this theory has been proved to be incorrect. The formation of a thrombus is merely a provision of nature to secure temporary hemostasis, and the final or permanent repair of the injury is accomplished by the proliferation of the formative cells of the tunica intima and tunica media. As soon as the circulation is arrested by the formation of the thrombus, the formative cells of the vessel wall begin to divide and form new cells, which infiltrate the blood clot and cause its gradual absorption. The mass of granulation tissue thus produced, undergoes vascularization from the vaso-vasorum, and finally becomes converted into mature cells. As long as a vessel is merely occluded by a thrombus, there is danger of secondary hemorrhage, and it is not until a permanent repair of the defect is accomplished through the agency of the formative cells that the patient is safe. The reason secondary hemorrhage was so frequent in the pre-antiseptic era, was because inflammation was usually present in the wound and the thrombi underwent disintegration before regeneration was complete. The reason secondary hemorrhage is now rare is because inflammation is rarely present in a wound and the aseptic thrombi remain in the ends of divided vessels until definite healing occurs. In the old days thrombosis was much more extensive than at present. In fact, after division of a vessel the blood usually coagulated back to the nearest collateral branch. Surgeons of that generation were afraid to ligate a vessel unless they had a space of at least an inch to accommodate the thrombus. In modern aseptic surgery, extensive thrombosis is not seen, and the operator is able to ligate a vessel close to a collateral branch or near its bifurcation with little or no risk of secondary bleeding. The treatment of injuries to blood vessels will be considered fully when we come to the subject of hemorrhage. Here all that need be said is that if the vessel is a large one and is only partially divided by the injury there is a possibility of closing the opening by sutures or a lateral ligature without completely obstructing its lumen. If the vessel is small and completely divided, its two ends should be ligated with fine aseptic silk or catgut. Large and important vessels, however, even when completely divided should be carefully sutured; and if done aseptically with accurate approximation of the three coats without protrusion of the suture material into the lumen of the vessel, union will occur without obstruction.

REPAIR OF NERVES.

The Central Nervous System or brain and spinal cord is composed of neuroglia and ganglionic cells. It is a structure of high development, hence has a very low vegetative capacity. For a long time it has been known that true repair after injury to the brain and spinal cord never takes place, but that defects due to injury, are restored by the substitution of connective tissue. It is now known that neuroglia is occasionally reproduced, but new ganglionic cells are never formed.

The Peripheral Nervous System is composed of nerve trunks. These are formed of nerve fibers, which consist essentially of an axis cylinder, the white matter of Schwann, and except in cases of nerves of special sense, of the neurilemma or primitive sheath. Lying in the white matter of Schwann and attached to the inner surface of the neurilemma are found large oval nuclei, which represent the formative cells of the part, and are termed neuroblasts. They proliferate normally to restore physiologic waste, and after injury to repair damage inflicted by traumatism. When Cruikshank first suggested that function could be restored to a divided nerve by suturing the ends together, he was ridiculed, but it is now known that nerve trunks covered by neurilemma possess high vegetative capacity. It has been proved that not only will the two ends of the same nerve unite, but that the ends of different nerves will unite and result in re-establishment of function, provided the nerves are both motor or both sensory, and provided they are covered and insulated by neurilemma. As yet there is no proof that the union of the end of a sensory nerve to the end of a motor nerve will be followed by any physiological result. Neither does regeneration occur in those nerves not covered by neurilemma. When a nerve is cut, there is degeneration of the fibers of the peripheral end throughout its entire length, and also degeneration of the terminal fibers of the central end, though to a limited extent. If, however, a nerve trunk of the neurilemmic variety is aseptically sutured, in such a manner that primary union occurs without the intervention of collateral connective tissue, regeneration occurs. In the process of union of a divided nerve there is first physical union by granulation tissue, the result of the proliferation of fibroblasts located in adjacent connective tissue, and then physiological union from proliferation of the neuroblasts found in the nerve fibers themselves. The fibroblasts in the endoneurium and perineurium proliferate and form granulations that bridge the gaps between the separated ends, the neuroblasts lining the neurilemma in the central end of the nerve then proliferate and form new nerve fibers, which penetrate the granulations and reach the proximal end of the nerve, thus re-establishing the broken circuit between its origin and distribution. Functional union is not accomplished until the distal end of a divided axone is brought in contact with a proximal axone which extends uninterruptedly from a ganglion cell body. The most favorable results are secured when the union is effected solely by the neuroblasts of the neurilemma without the intervention of the fibroblasts of connective tissue. Hence every nerve union should be surrounded when practicable by a guard against collateral connective tissue. When this is successfully done and infection does not occur, end to end union of neurilemmic nerves can be made uniformly successful both anatomically and physiologically. Experiments prove that in favorable cases it takes about three weeks after a nerve is sutured, for any evidence of restoration of function to be noted. It is usually eleven or twelve weeks before restoration of function is complete. The nearer to the spinal cord a nerve trunk is divided, the longer is the time required for regeneration. The order of functional regeneration is: (1) trophic, (2) sensory, (3) motor. There is no such thing as the immediate union of a nerve, and the cases reported in which there was rapid return of function after the division of a nerve, are due to anastomosis of the peripheral branches of the cut nerve with the branches of another nerve that was not cut.

When a nerve endowed with an important function is divided, it should be sutured. If the operation is done immediately after the injury it is called "primary nerve suture." If it is done some weeks or months afterwards it is called "secondary nerve suture." If the sutures are passed through the end of the nerve it is spoken of as the "direct method." If the sutures are passed only through the fibrous sheath it is spoken of as the "indirect method." The results of nerve suture so far as the restoration of function is concerned, depend upon the amount of separation that exists between the divided ends, the nearness of the injury to the terminal distribution of the nerve, the promptness with which sutures are applied, and the existence or absence of septic complications during the healing of the wound.

The operation of primary nerve suture is easy, and the results very satisfactory. The ends of the divided nerve are readily found, do not require to be freshened, and can often be approximated without tension. Direct sutures of fine silk or catgut are inserted with a round cambric needle, and their ends tied and cut short. The wound is closed and the part immobilized. After the lapse of several days when union is well begun, the muscles should be treated by gentle massage, passive motion and mild galvanism. If successful, there is evidence of beginning return of function in about three weeks, and restoration of normal condition in about three months. After suture of a mixed nerve, it will be noted that sensation returns sooner than motion.

The operation of secondary nerve suture is more difficult and uncertain, and yet even this operation frequently yields satisfactory and brilliant results. The part should be rendered bloodless by means of an elastic bandage, the nerve trunks found and their ends dissected out of the cicatricial mass in which they are embedded. The ends of the nerve should then be sufficiently resected to expose the normal nerve fasciculi and brought into as close apposition as possible and sutured. The failure of secondary nerve suture is usually due to the difficulty in getting the ends together, owing to either loss of tissue at the time of injury or subsequent retraction and contraction of the nerve cord. This may be overcome in one of several ways:

1. *By Stretching.* The two ends of the nerve may be grasped by the fingers or by padded forceps and forcibly pulled upon, and in this way lengthened sufficiently to secure approximation.

2. *Suture a Distance.* When despite stretching the ends cannot be brought together, union can often be secured by passing catgut sutures between the divided and separated ends and tying them. This fixes the ends of the nerve as near together as it is possible to get them, and the bundle of strands of catgut is a bond between them, which is utilized as a scaffolding on which the new cells are deposited.

3. *Suture Tubulaire.* Sometimes the ends of the divided nerve are introduced and fastened into a decalcified bone tube or a segment of artery from a calf. By this means relative approximation is effected and all the cells proliferated by the revivified ends of the nerve are caught and carried in the direction desired.

4. *Nerve Grafting.* Efforts have been made to restore the continuity of a nerve by grafting a section of another nerve between its two ends, and to restore the function of a nerve by grafting the end of the proximal portion to an adjacent nerve, but none of these expedients have yielded satisfactory results. Lateral apposition or end to side approximation of nerves gives only an occasional axis cylinder contact and only a small percentage of the axones will regenerate.

5. *Flap Operations.* Numerous flap operations have been tried on the lower animals, but while they all restore the mechanical continuity of the nerve, none of them are able to restore its physiological function, as they fail to unite an unbroken nerve filament.

6. *Shortening of Bone.* In some cases where the restoration of nerve influence is of paramount importance, as in an extremity, and the divided ends of the nerve cannot be brought together by less radical methods, a portion of the shaft of the bones is resected and easy and accurate end to end apposition of nerves thus secured.

REGENERATION OF BONE.

Bone is one of the hardest structures in the body. It is composed of both organic and inorganic material. It occurs in two forms, the compact and the cancellated, but while these differ macroscopically they are found to be the same microscopically.

Bone is covered externally by a vascular fibrous membrane called the periosteum and, if it contains a medullary cavity, it is lined internally by a somewhat similar membrane, called the endosteum. The histological structure of bone and the existence of Haversian canals, lacunæ and canaliculi need not be discussed. The formative cells of bone are found in the periosteum, the endosteum and the lacunæ, and are called osteoblasts. The periosteum is especially important in furnishing these cells and hence the importance of its preservation in cases of fracture and when operating on bones. When bone is injured, the osteoblasts proliferate, giving the tissue a high vegetative capacity. If a fracture of a long bone occurs, there is invariably laceration of adjacent soft structures attended by bleeding and the accumulation of coagulated blood between the ends of the fragments. Within forty-eight hours, the connective tissue cells begin to proliferate and form granulation tissue to effect repair. This granulation tissue is called callus. At first it is soft and forms an indefinite swelling about the seat of injury. Later the mass becomes smaller, firmer, cartilaginous in appearance and has a well defined outline, finally it becomes converted into bone by the action of the osteoblasts and deposition of lime salts. The callus developed after the fracture of a long bone may be divided into three varieties: First, the *external or splint callus*, or that formed on the outside of the bone by the osteoblasts of the periosteum; second, the *internal or pin callus*, or that formed in the medullary cavity of bone by the osteoblasts of the endosteum; and third, the *intermediate or definitive callus*, or that formed between the broken surface of bone by the osteoblasts of the lacunæ. The external and internal callus serve to temporarily fix and immobilize the fragments. They are not permanent and do not undergo ossification, but are removed after they have fulfilled their mission, the absorption being accomplished in some undetermined way by cells called osteoclasts. The intermediate callus, or that thrown out between the broken surfaces of bone, however, is permanent, undergoing ossification and firmly uniting the fragments one to the other.

A broken bone, properly set and splinted, will usually heal.

Sometimes ossification does not follow. When this occurs, the condition is spoken of as either delayed union or non-union. Delayed union is that in which reparative action is present, but owing to lack of nutritive vigor, callus is either tardy in development or imperfect in its transformation. Non-union is that in which the result is either a ligamentous union or the formation of a false joint. The division of ununited fractures into delayed union or non-union is based on the fact that cases in the first class can be cured without an operation, by making more active the reparative forces already in existence, while cases in the second class cannot be cured except by an operation which freshens the rounded ends of the bones, opens up their medullary cavities and changes the existing passivity to the activity of a recent fracture.

The causes of delayed union or non-union of a fracture are usually classified under the heads of general and local. Under the first, authorities give a long list of constitutional conditions, such as age, pregnancy, lactation, acute infectious diseases, starvation, loss of blood, rickets, marasmus, and syphilis. All except the last are of doubtful influence, for it is a strange but authenticated fact that failure of a fracture to undergo proper ossification is more apt to be observed in a vigorous adult than in the debilitated, the marasmic or the aged. While it is true that syphilis and fractures are both so common that they often co-exist without detrimental influence one on the other, still patients with delayed union so often respond to anti-syphilitic treatment that it is now the usual practice to prescribe iodide of potash as the first effort to secure union, and this whether any history of specific infection can be obtained or not. If it does no good it does no harm, and as we all know, syphilis, like accidents, is likely to occur in the best regulated families, and patients suffering with the disease are sometimes ignorant or untrustworthy in their statements. It must be understood, however, that it is the constitutional effect of the disease and not local syphilitic processes in the bone which antagonize union; for syphilitic bone disease is usually hyperplastic in nature.

Under the local causes of delayed union or non-union, and these are by far the more important and usually the cause, may be mentioned marked displacement or wide separation of the fragments; interposition of muscle, fascia or foreign bodies between the fragments; defective nutrition through faulty innervation or deficient blood supply; infection and suppuration, destroying or preventing the formation of callus; and finally, defective immobilization or premature passive motion. In fact, delayed union may be due to any defect in the primary treatment of a fracture, such as failure to effect accurate reduction and to secure proper immobilization, too tight bandaging, undue pressure of splints, frequent removal of the dressings, for the purpose of inspection, or allowing the patient to use the limb too soon on account of the unfounded fear that prolonged fixation endangers the function of the adjacent joint. The local treatment of delayed union or non-union should be based largely on the result of an X-ray examination. In some cases it will appear probable that the patient can be cured without subjecting him to an operation; in other cases, it will at once be obvious that nothing short of operative surgery will prove effective. The following is a brief summary of local methods that have been advised: First, light elastic constriction above and below the fracture, producing more or less hyperemia; second, active use of the limb encased in an immobilizing dressing of plaster of paris; third, percussion of the limb by the surgeon with a rubber mallet, or by instructing the patient to strike his heel on the floor if the fracture be in the lower extremity, or pound the hand or elbow on a table if it be in the upper; fourth, injection of from three to ten drops of 10 per cent solution of chloride of zinc between the ends of the fragments by means of a hypodermic syringe; fifth, administration of an anesthetic and forcibly tearing loose fibrous adhesions, affecting accurate apposition and treating as a recent fracture; sixth, subcutaneous drilling of the ends of the fragments, the perforations opening up the medullary space and the small particles of bone detached acting as a beginning of repair; seventh, resection of the ends of the bone, accurate adjustment of their freshened surfaces, and the maintenance of the fragments in correct position by means of sutures, nails, medullary splints or bone ferrules—all reinforced, by a rigid external dressing, which should also immobilize the adjacent joints.

LECTURE IX.

INFLAMMATION—IMPORTANCE—DIFFICULTY OF STUDY—NATURE OF PROCESS—DEFINITION—CAUSES AND PATHOLOGY OF INFLAMMATION.

The subject of inflammation is one of vast theoretical and practical importance, since upon its proper comprehension depend the student's grasp of pathology and the surgeon's successful treatment of the majority of his patients. Consequently it is unfortunate that authorities do not agree in their teachings, but differ, first as to the nature of the process—whether it is conservative or destructive; second, as to the character of its causes—whether it is due only to microbic infection or to mechanical and chemical irritants as well, and third, as to what is included in the term inflammation, and what should be excluded and described under other processes.

Some contend that inflammation is a pathologic process, destructive in its tendencies and opposed to the natural restoration of tissue from injuries inflicted by accident or disease. Others contend that inflammation is a physiologic process, conservative in its tendencies, and, in fact, is an effort of nature to defend itself against injurious influences and to repair damages inflicted upon its structures. Again, many practical surgeons claim that all inflammation is bacterial in origin, and that the process never develops except as a result of microbic infection; while others, among them the most famous pathologists, insist that irritants, whatever be their nature, are sufficient to produce the succession of histological changes that are characteristic of inflammation. Finally, some of the most recent writers earnestly contend that hyperemia is not a part of inflammation, and endeavor to draw a sharp line of differentiation between the two processes. They claim that hyperemia is essentially the opposite of inflammation, in that the one is a physiologic process inaugurated by natural forces and aids the tissue in its effort to effect repair, while the other is distinctly a pathologic process, destructive in its tendencies and opposed to the inherent recuperative power of tissue. Such is the contradictory status of the present views of inflammation. There is no possibility of a compromise, and a teacher must endorse one school or the other. Having in justice to the student made the foregoing statement, I will without apology teach that theory which seems to me to be most logical, avoiding the introduction of arguments except where unavoidable.

DEFINITION OF INFLAMMATION.

Inflammation may be said to embrace the abnormal conditions that are caused by the action of irritants upon the histological elements of the blood and other living tissues. Sanderson defines it as "the succession of changes which occur in a living tissue when it is injured, provided the injury is not of such degree as at once to destroy its structure and vitality." Park states that "Inflammation is an expression of the effort made by a given organism to rid itself or to render inert noxious irritants arising from within or introduced from without." It will be noted that the definitions quoted either express or imply that inflammation is a "*protective*" effort of nature against "*noxious irritants,*" and the nature of the irritant is intentionally left indefinite, because it is believed it is not invariably microbic. As an example of the definitions employed by the opposite school may be cited the one formulated by Nancrede, "Inflammation consists in the series of results caused by microbic interference with the normal process of repair in injured living tissue."

CAUSES OF INFLAMMATION.

Inflammation is a reaction against irritation, hence the cause of inflammation may be said to be an irritant. Irritants may be microbic, mechanical, chemical or thermal. As an example of a microbic irritant may be cited inflammation the result of infection with pus germs, as an example of inflammation from mechanical irritation, the changes which ensue after a blow or bruise, as an example of inflammation from chemical causes, the reaction after the application of turpentine, croton oil or nitric acid, and as an example of inflammation from heat or cold, the symptoms which develop after a burn or frost bite. It is a fact that bacteria are by far the most frequent causes of inflammation but the existence of the other causes cannot be denied and the scientist in his teaching should not substitute the major part for the whole. After all, infection reduced to its last analysis represents a chemical injury to tissue, as bacteria act by producing toxins which are chemical irritants and combine with the protoplasm of the cell. It is an unquestioned fact that inflammation can be produced by the injection of toxins free from the presence of bacteria. Here assuredly we are dealing with a simple chemical agent. Many other laboratory experiments could be quoted to prove that inflammation may be caused by irritants other than microbic, but it is deemed unnecessary to do so. The inconsistency of the opponents to this theory is shown by the fact that the very author who denies the identity of the reaction following the application of mechanical and chemical irritation with the results following microbic infection, will in the next paragraph describe the phenomena of inflammation as observed in the experiment of irritating the delicate mesentery of a frog by handling it or touching it with nitrate of silver.

THE NATURE OF INFLAMMATION.

Inflammation is a reactive process on the part of living tissue, due to the presence of some injurious agent, bacterial or otherwise. Usually inflammation is the effort of nature, to defend the general system from infection, since usually the irritant is microbic. It makes little difference so far as the truth of this theory is concerned, to admit that nature in carrying on her defensive campaign often inflicts damage to herself. The demands of the situation may render harsh measures necessary. Her supply of provisions may be so excessive as to embarrass communication; her soldiers may be so overcrowded as to impede their movements;

her leucocytes may be sent to certain death, her bridges may be burned and her territory sloughed from her, but victor or victim, the process of inflammation is a battle of rebellion.

PATHOLOGY OF INFLAMMATION.

An inflamed part is painful and swollen, red and hot, and its functions are more or less perverted. These symptoms are the result of the pathological changes which have ensued in the area involved. If we paralyze a frog with curare and draw a loop of intestines through an incision made in the abdomen, we obtain a thin, transparent membrane, in which the circulation can be readily studied. If the mesentery be irritated with the point of a silver nitrate pencil and the area placed beneath the microscope, we can watch the changes which occur from the very inauguration of the artificially produced inflammation to its termination in resolution or further destruction. This has been done many times, and all observers agree that the changes which occur and which embrace the phenomena of inflammation may be practically classified, as follows:

A. Certain Changes in the Size of the Blood Vessels and in the Blood Circulation.

1. Ischemia.
2. Hyperemia.
3. Congestion.
4. Stasis.

B. Certain Changes by which the Elements of the Blood which were Intravascular become Extravascular.

1. Transudation.
2. Exudation. *a.* Emigration. *b.* Diapedesis.
3. Rhexis.

C. Certain Changes in the Extravascular Blood Elements and in the Perivascular Tissue.

1. Changes in the tissue cells.
2. Changes in the blood elements.
   a. Transudate. *b.* Exudate.

STUDY OF THE NORMAL CIRCULATION.

If we examine the normal circulation as it occurs in the vessels of the transparent mesentery of a frog we can see the arteries with their rapidly pulsating current of blood, and near by a small vein in which the blood flows with a more steady movement. The capillaries are not readily seen until inflammation causes their dilatation, but careful observation will detect channels connecting the arterioles and venules, through which a few blood corpuscles occasionally pass. If the flow of blood through a small vein is watched there is little difficulty in distinguishing two currents, the axial and the peripheral. The axial or central current is rapid and conveys the red blood corpuscles which have about the same specific gravity as the blood plasma, while the peripheral current between the axial current and the vessel wall, is considerably slower, and in this current the white blood corpuscles are conveyed, their rotary motion being due to their contact with the vessel wall. This is explained by the physical law owing to which if a fluid containing in suspension solid particles, is forced through a capillary tube, the heaviest particles are carried along the central current, while those specifically lighter, seek the peripheral current.

As is well known to the student of physiology, the vascular system is controlled by the vasomotor nerves and perivascular ganglia. The nerves can be divided into two groups, all originating from a certain part of the brain, but after traversing the cord, a large majority join the sympathetic system by means of the rami-communicantes and constitute the "indirect supply," or vasoconstrictors, while a small minority do not join the sympathetic, but leave the cord through the posterior or sensory root and form a part of the spinal nerve constituting the "direct supply" or vasodilators. The perivascular ganglia constitute a peripheral vasomotor mechanism independent of the center, and capable of influencing the caliber of vessels in tissue actually separated from the brain and spinal cord, as in a transplanted flap. The vasoconstrictor nerves and perivascular ganglia are in continuous action, and keep the muscular walls of the blood vessels in a state of tonic contraction. The vasodilator nerves are not always in action, but are called into play in unusual conditions.

Having reviewed the normal circulation and the nervous mechanism by which it is controlled in health we now take up the description of the abnormal changes which are seen in inflammation, discussing them under the headings in the classification already given.

A. Certain Changes in the Size of the Blood Vessels and in the Blood Circulation.

1. *Ischemia.* The first change which is observed after the artificial production of inflammation is a fleeting contraction of the lumen of the vessels caused by stimulation of the vaso-constrictor nerves, and as a result there is a temporary blanching of the tissues. This is the stage of ischemia.

2. *Hyperemia.* Following almost immediately upon ischemia there is a wide dilatation of the blood vessels from the action of the perivascular ganglia, and this dilatation of the vessels is accompanied by an increased velocity of the flow of blood through them. Dilatation is first noticed in the small arteries, afterwards in the veins and capillaries, and keeps increasing for from fifteen minutes to two hours. The blood is brighter and more arterial in color and obviously greatly increased in amount. The blood corpuscles circulate in their respective streams and the condition is one of exalted physiological activity. This is the stage of hyperemia.

3. *Congestion.* There is next a gradual slowing of the blood current, which is first noticed in the capillaries and soon afterwards in the venules. This is not due to contraction of the vessel walls, but to overcrowding of the venules with blood corpuscles, which mechanically obstruct them. The blood current becomes more sluggish and the column of blood corpuscles broader. Owing to the slowing of the stream, the leucocytes in the peripheral current are not forced onward with the same momentum, but are dropped here and there on the vessel walls. Some of them appear to be momentarily attached, when they are again detached

by the force of the current and rolled away by another leucocyte. As the process advances, it appears as if the viscosity of the leucocytes was gradually increasing, since more and more of them adhere while fewer and fewer are detached. The vessels now appear as if the internal surface of their walls was paved with leucocytes and their lumen much diminished by this mural implantation. It appears as if obstruction would occur every minute, the capillary stream becoming completely arrested for a few seconds and then the current overcomes the obstruction, and again moves forward in the normal direction. The smallest arteries exert themselves to the utmost to clear the way, and pulsation can be seen where in a normal condition it is absent. The stage of hyperemia has given place to that of congestion.

4. *Stasis.* The last change observed is the complete arrest of the blood current. The vessels remain widely dilated, but the great accumulation of leucocytes and their adhesion to the interior of the vessel walls causes more and more obstruction, until finally, the space for the axial current becomes too small for the passage of the colored corpuscles, when complete arrest of the circulation takes place. As soon as this occurs, the red and white blood cells become mixed and no longer occupy their respective positions in the vessels. Congestion is now said to have terminated in stasis.

B. Certain Changes by which Elements of the Blood which were Intravascular become Extravascular.

The action of the noxious cause of inflammation shows its most decided effect on the capillary wall, altering the structure so as to increase its permeability and to permit the escape of the contents. A capillary is a minute vessel, or channel, composed of a single layer of endothelial cells, held edge to edge by an amorphous, cement-like substance. When capillaries undergo alteration and are subjected to distention, as in inflammation, the cement substance yields in many places and in consequence, minute openings occur, called stomata. During the observation of inflammation artificially produced in a transparent membrane, there will be seen the passage of the vessel contents through the vessel walls to the perivascular tissue. The fluid portion of the blood passes out by transudation; the solid element of the blood by exudation.

1. *Transudation.* This is the escape of the fluid element of the blood from the vessel. The plasma normally passes in small quantities from the capillaries, to convey nutrition to neighboring cells. In inflammation, owing to the existence of stigmata and stomata in the capillary wall, it escapes more rapidly and in greater quantities. In fact, it leaks out as would water from a defective hose.

2. *Exudation.* This is the escape of the corpuscular elements of the blood from within the vessel to without the vessel. As the white blood cell and the red blood cell adopt different methods of passage through the minute openings the process is complicated.

a. Emigration. The white blood cell or leucocyte passes through the inflamed capillary wall by what is known as emigration. For this to take place there must be (1) alteration of the capillary wall, or the existence of a minute opening; (2) mural implantation of the leucocyte, or its arrest opposite the opening; (3) permeability of the lumen of the capillary vessel, so that there is some intravascular pressure; and (4) ameboid movement of the leucocyte, for the process is not a passive one but is largely effected by the change in the shape of the corpuscle and the physical effort it makes to escape. In emigration a white blood cell may be seen to become implanted on the inner surface of the vessel wall, insinuate an arm into a stigma and gradually pass its body through the opening which may be several times smaller than its own diameter. Frequently one leucocyte after another may be seen going out through the same opening.

b. Diapedesis. The red blood cell, or erythrocyte, passes through the inflamed capillary wall by diapedesis. As the colored corpuscles possess practically no ameboid movement, this process is purely a passive one on their part. They drift inertly in the plasma stream and their passage through stigmata or stomata is owing to their being carried with the current in which they float. This is proved by the fact that, despite the larger diameter of the white blood cell compared to the red blood cell, the white blood cell is the first of the two elements to escape, and the red blood cell is only found outside of the blood vessel in the late stage of acute inflammation, a time at which the stigmata and stomata have been much enlarged by the constant passage of the emigrating leucoytes.

3. *Rhexis.* Occasionally, in addition to the passage of the constituents of the blood through stigmata and stomata of the vessel wall by transudation and exudation there is the escape of blood in its entirety through a large tear or defect in the vessel wall; a hemorrhage, so to speak, and this is termed rhexis.

It is somewhat remarkable that the character of the irritant determines to a certain extent the form of leucocyte most abundant in the exudate. In many of the infections, notably the pyogenic, the polymorpho-nuclear leucocyte is abundant, while in other forms the lymphocyte predominates. What factor or factors determines this consideration we cannot say with the present extent of our knowledge. But given an acute suppurative inflammation, we expect the polymorpho-nuclear cell to be abundantly present; and given a chronic, less acute irritant, we expect to find the lymphocyte the characteristic cell infiltrated.

C. Certain Changes in the Extravascular Blood Elements and in the Perivascular Tissue.

At this point in the process of inflammation, the fibers of the tissues are swollen and the meshes distended with coagulated lymph, and infiltrated with small round cells.

1. *Changes in the Tissue Cells.* If the inflammation invades fibrous tissue, the fibers of the original tissue are swollen, and softer than usual, and here and there terminate abruptly as if broken off. If an organ composed of epithelial cells is the seat of infection, the epithelial cells are granular, opaque, and frequently contain fatty granules, a condition spoken of as "cloudy swelling."

2. *Changes in the Blood Element.*

a. The Transudate. The fluid and coagulated lymph found in inflamed tissues is the blood plasma, or liquor sanguinis, that has escaped from the vessels by the process of transudation. A part undergoes coagulation by virtue of the fibrinogen. The transudate by its escape from the vessels, relieves intravascular tension, averting the threatened interruption of the circulation and the danger of gangrene from pressure. It also dilutes the irritant present in the tissues, carries with it antitoxic and antibacterial properties, and probably furnishes some nutrition to the cells of the area. The coagulated portion retards the dissemination of bacteria and lessens diffusion of the toxin into remoter tissues.

b. The Exudate. The exudate is composed of the white blood cells or leucocytes that have escaped from the neighboring vessels by the process of emigration. In addition there are other small round cells found, which, though hardly to be distinguished morphologically from the leucocyte, have a different origin. They are newly formed or embryonal cells, the result of the proliferation of the formative cells of the part. Hence it will appear that the numerous small round cells found in the inflamed area may come from one of two sources or from both combined.

The function of the leucocytes is to attack the infecting organism if it be the cause of the inflammation or to remove dead tissue if the inflammatory process follows upon a non-microbic cause of cell destruction. It is not improbable that the phagocytes, as these fighting leucocytes are termed, in addition to their phagocytic action, liberate some antitoxic or antibacterial body that further aids in subduing the infection. The embryonal cells have no part in the inflammatory process, strictly speaking, but are thought to be the result of the first effort of nature at repair, an attempt at reconstruction inaugurated before victory has been achieved.

LECTURE X.

THE STATUS OF HYPEREMIA—THE SYMPTOMS OF INFLAMMATION—LOCAL: PAIN, HEAT, SWELLING, REDNESS, IMPAIRED FUNCTION—GENERAL: FEVER AND ATTENDING COMPLICATIONS—TERMINATIONS—DIAGNOSIS AND PROGNOSIS OF INFLAMMATION.

The question of the relationship of hyperemia to inflammation has been purposely avoided under what might seem its proper heading, because it was desired to present the subject of the pathology of inflammation unbroken by the insertion of divergent views. It will now be briefly discussed.

As already stated, there are many authorities who claim that inflammation is a destructive process and consequently opposed to the repair of injuries received by tissue. Finding their arguments refuted by the manifest tendencies of hyperemia to aid regeneration, they insist that the process is not a part of inflammation but a distinct and separate phenomenon. In other words, that hyperemia is not a stage of inflammation, as has been taught, but is essentially the antithesis of inflammation. In conformity with the position taken in these lectures, namely, that inflammation is a defensive, and therefore a conservative process, and that hyperemia is merely one of its several stages, the following is submitted.

Hyperemia is a condition of local plethora in which the excess of blood is mainly upon the arterial side of the circulation, a distention of the capillaries by arterial blood, in contradistinction to the later stage known as congestion, in which the blood present is essentially venous. The causes of hyperemia or excess of blood on the arterial side of the local capillaries, are found upon investigation to be the same, fundamentally, as those of inflammation, namely, various irritants, bacterial or non-bacterial.

As it is most probable that the exciting cause acts through the vasomotor system, it is believed that irritation may produce hyperemia by withdrawing the stimulus of the vasoconstrictors (neuroparalytic hyperemia), or by stimulating the vasodilators (vasotonic hyperemia). As an example of the hyperemia produced by physiological irritants, may be cited the effect of food when introduced into the healthy stomach and the increased flow of blood to the part, which results. As an example of hyperemia produced by thermal influence, may be cited the effect of exposure to excessive heat. As an example of hyperemia produced by certain chemical bodies, may be cited the effect of the application of nitrate of silver to the mesentery of the frog. Whether hyperemia will cease to exist and the tissues involved be restored to normal by what is known as resolution, or whether the process will progress and go through the several stages described as inflammation, will depend on the early withdrawal of the cause on the one hand, or its continued action on the other. Withdraw promptly the cause at the stage of hyperemia, and whether the irritant be infectious or non-infectious the inflammatory process will cease. But continue the injurious action of the cause, whatever be its nature, and hyperemia is succeeded by the other and unquestioned stages of inflammation. This is not merely theory, but can be shown to be true by practical illustration. Take the physiological hyperemia of digestion. If the ingesta, the etiological irritant, be removed by the normal process of digestion, hyperemia promptly subsides. If, however, the food remains in the stomach, the continued irritation results in gastritis or inflammation of the stomach. Take the mesentery of the frog and irritate it with the nitrate of silver. Withdraw the cause at the stage of hyperemia and you can see the process resolve. Continue the cause, and under the microscope you can observe hyperemia progress into fully developed inflammation.

Unless the cause is withdrawn, hyperemia tends to progress to the other phenomena of inflammation. The etiology of the two is the same, therefore one must be a stage of the other. If the one be conservative, it is only logical to suppose that its other stages are likewise conservative, and really are only a further expression of the efforts made by nature to rid herself of a noxious irritant. Granting the foregoing statements, there is no escape from the conclusion that the only difference between hyperemia and inflammation is that dependent upon the continuance or withdrawal of the active, exciting cause.

SYMPTOMS OF INFLAMMATION.

The symptoms of inflammation are both local and constitutional. The time-honored classification of the local symptoms under the heads "*dolor, calor, rubor, tumor et functio læsa*" will be adopted. The constitutional symptoms will be discussed under the head of *fever and its attending complications*. We will take the symptoms up in order, referring again to what was taught in the last lecture whenever the association of the pathological changes with the symptomatic result will serve to impress the former or explain the latter.

A. Local Symptoms.

1. *Pain* is usually one of the first of the local symptoms of inflammation. It is caused by pressure on the sensory nerve terminals in the part, from the increased tension due to the transudation and exudation. It is due also, in some cases, to direct extension of the inflammatory process to the nerve fibers themselves. Pain, though always present, varies in degree, character and location. The degree of pain suffered by the patient is influenced by the temperament of the individual. An amount of inflammation which may cause only discomfort in a plethoric subject will often produce excruciating agony in a patient of nervous temperament. It is not a question so much of the ability of an individual to bear pain as it is a question of the perceptive power to appreciate it, that makes the difference between the so-called "good" and "bad" patient. The personal equation left out of the problem, the degree of pain is largely dependent upon the anatomical part involved. As pain is due to pressure on nerve terminals, it is logical to infer that it will be greatest where tissue is least distensible and most abundantly supplied with sensory filaments, and this is found to be true. Pain is the

pronounced symptom in unyielding structure like bone, and in sensitive organs like the eye-ball or finger tips. It is comparatively trivial in loose, insensitive parts like the areola tissue of the abdomen. The character of the pain also varies, and man's vocabulary has been taxed to find words to describe its variations in this respect. Thus, it is said to be "burning," when it attacks the skin, "stabbing" when it invades serous surfaces, "throbbing" when suppuration threatens, and "dull," "aching," "boring," when it involves bone.

In certain chronic, inflammatory troubles, pain may be absent in the day and present at night—nocturnal pain. The location of pain varies. Usually it is referred to the seat of inflammation, but often it is said to be in some other part of the body—"reflected" or "radiated" pain. Thus, in Potts' disease of the spine, the inflammatory focus is in the vertebral column, but the patient complains of pains in the abdomen. In morbus coxalgia, the disease is in the hip joint but the pain is said to be above and to the inner side of the knee. In the early stages of appendicitis, the inflammation is in the lower right quadrant of the abdomen, but the pain is felt most severely about the umbilicus. These and other illustrations that could be mentioned, are due to the irritation of the nerve trunk, the source of irritation being referred by the brain to the terminal distribution of the nerve, or to irritation of one branch of a sensory nerve, and the source being referred to another branch of the same trunk. In locating the seat of inflammation, tenderness or the pain produced by pressure is much more reliable than spontaneous pain. The point of greatest tenderness usually indicates the primary focus of infection, and the area of tenderness usually shows the boundaries of the inflammatory area. Firm pressure usually relieves neuralgic pain, while it increases pain when it is caused by inflammation. Light pressure increases the pain in a part the seat of functional disturbances, while it does not markedly affect the pain resulting from inflammatory lesions.

2. *Redness.* The Caucasian's boast that he is a white man, is unfounded. As long as the blood circulates in his skin it is pink, and it is only when the superficial capillaries are empty, as in

shock or death, that it is white. Just as the normal amount of blood in the part gives it the flesh tint of health, so does an excess of blood in a part give it the redness of inflammation. Although the flow of blood to and from the part varies in the three stages of inflammation, there is this fact common to them all—there is more blood in the part. The proof that the change of color in inflammation is due to the increased amount of blood in the part is that firm pressure, continued until the vessels are emptied, will blanch the tissues, and that the color will return as soon as the pressure is discontinued long enough to allow the vessels to refill. In the early stages of inflammation, the color is of a bright scarlet from the excess of arterial blood. In the later stages, there is a bluish, purplish tinge from the impeded access of arterial and the retention of an excessive amount of venous blood. In the so-called hemorrhagic form of inflammation, where the exudate contains an unusually large number of red corpuscles, the tissues may become more or less permanently pigmented from the disintegration of the red corpuscles and the liberation of hemoglobin.

3. *Swelling* is nearly always present in inflammation. It is due to the dilatation of the local blood vessels and to the saturation of the tissues with inflammatory transudate and exudate. Two bodies cannot occupy the same space at the same time, and if the size of the blood vessels is doubled and the amount of fluid and cellular elements largely increased, the locality must become swollen. The amount and the rapidity with which swelling occurs, varies with the distensibility of the tissue. In the bone and other dense structures it is inconspicuous and slow, while in loose tissues like the eyelid, scrotum or vulva, it is marked and rapid. If the inflammatory exudate is excessive the part is firm and "cake-like." If the transudate is in excess it is "dough-like" and pits on pressure.

4. *Heat.* Increase of local temperature seen in inflammation, like redness, is also due to the increased amount of blood in the part. At one time, it was thought that it was due to chemical changes or combustion, but it has been proven that it is due to the increased afflux of blood to the part. The temperature of the inflamed area is never in excess of the temperature of the

blood. It must of course be remembered, however, that in inflammation the blood may be warmer than normal, owing to coincident fever, and that the part may feel hotter to the patient than it really is, from a hypersensitive condition of the nerves distributed to the locality. A fall in the local temperature may be a favorable indication, pointing to termination by resolution. It may, however, be an unfavorable symptom, indicating arrest of circulation and threatened or actual termination in gangrene.

5. *Impaired Function* or, to be more accurate, disturbance of function, is the last of the local symptoms to be noted. It may be in the direction of temporary increase of the physiological function of an organ from overstimulation, as is seen in the increased secretion of mucous in catarrhal inflammation, or it may be in the direction of diminution of function, as in the case of inability to retain urine in cystitis, or to tolerate light in retinitis.

B. Constitutional Symptoms.

The constitutional symptoms of inflammation are fever and its attending complications. Toxic substances produced by the microbes in the inflammatory area are rapidly absorbed by the blood and carried throughout the system. They are highly pyrogenous substances, and acting on the thermic centers of the brain, disarrange the delicate mechanism by which the normal temperature of the body is maintained. Whether they stimulate heat production or diminish heat elimination makes but little practical difference—the result is fever. The febrile condition is attended by other general derangements, such as a feeling of prostration, chilliness or rigors. The pulse becomes rapid. There is pain in the back and limbs. The skin becomes dry, the tongue coated, the bowels constipated. There is loss of appetite, nausea, and perhaps vomiting. The urine is scant and high colored. Sometimes there is insomnia, and again drowsiness. Sometimes delirium and again coma. Leucocytosis exists and is of considerable importance as a sign.

TERMINATION OF INFLAMMATION.

Inflammation may terminate in one of three ways: by (1) resolution, (2) suppuration, (3) gangrene.

1. *Resolution* means that the symptoms gradually subside, and the function and structure of the tissue will be more or less perfectly restored to the normal condition. In other words, the inflammatory products are removed, and the damage suffered by the tissue is repaired. Many of the leucocytes that have retained their vitality, return into the circulation, either through the walls of a capillary or through a lymphatic vessel. Other leucocytes, embryonal cells and colored corpuscles are disintegrated and absorbed. Fibrin undergoes granular degeneration and, together with edematous fluid, is removed from the tissues. The defects in the capillary walls are repaired, the circulation is re-established and the part eventually shows little evidence of the drama that has been enacted within its confines. Resolution is the happiest termination of inflammation, and is only possible when the irritant is withdrawn early and, as a consequence, the amount of transudation and exudation is limited.

2 *Suppuration*, the second of the three terminations of inflammation, cannot be described at this point without anticipating future lectures. It may be said, however, to consist in the death of the leucocytes and embryonal cells and their transformation into pus corpuscles, the liquefaction of the fibrin and the conversion of it, together with the fluid transudate, into pus serum, and the combination of the two into a substance known as pus. When suppuration takes place and pus is formed, there is extensive destruction of the pre-existing cells of the inflamed tissue. A defect is created which requires considerable time to be repaired and the result is the formation of a scar or cicatrix.

3. *Gangrene* is the third and most disastrous termination that may follow inflammation. It means death of the tissue and is usually indicative of infection of great virulency in tissue of lowered vitality. Death of cells that compose the part is due either to pressure or poison or both combined. If the tissue is unyielding and the exudate and transudate abundant, the pres-

sure may be sufficient to stop the circulation, and blood no longer conveying nutrition, the cells die of starvation. Again, the toxin produced by the germs may be of such potency that the cells, bathed in fluid saturated with the poison, may die of toxemia. It will be noted that when gangrene takes place, it usually begins in the center of the inflammatory area, because here the cells have been longest subjected to pressure and first exposed to the action of toxins. Like suppuration, the subject of gangrene will be discussed more fully later.

THE DIAGNOSIS OF INFLAMMATION.

Usually the symptoms of inflammation are so well marked that there is no difficulty in making a diagnosis. In some cases, however, there is the absence of one or more of the cardinal characteristics, and then it is important to thoroughly weigh those that are present. Fever varies greatly as the toxins of different germs act with different phlogistic power. Suppurative inflammation caused by infection with the micrococcus pyogenes aureus is not attended by so high a temperature as when produced by the staphylococcus or streptococcus. Fever rises or falls with the increase or decrease of the infective process. Of the local symptoms, the one of greatest diagnostic importance is the increased heat in the part. A local rise in the temperature is more indicative of inflammation than a general elevation, as the latter may be due to many causes, while the former, if permanent, is strongly suggestive of inflammation. In doubtful cases the use of a surface thermometer will often differentiate between an inflammatory mass and a malignant growth.

THE PROGNOSIS OF INFLAMMATION.

The prognosis in a given case of inflammation is based upon:

1. *The Character of the Cause.* As illustrative, it is merely necessary to recall the well-known facts that infection with certain species of micro-organisms such as the gonococcus, does not often cause death, while infection with others such as the bacillus tetanus or anthrax is commonly fatal.

2. *The Anatomical Tissue Involved.* Infection of certain anatomical tissues is more dangerous than the inoculation of other localities with the same germ. For instance inflammation of the vocal cords would be more likely to cause death from asphyxia than inflammation of the tonsils. Inflammation within the cranium would be attended by more hazard from pressure on the brain than a similar amount of extra-cranial disease.

3 *The General Condition of the Patient.* The strength, health and age of the patient have an important bearing on the result of the inflammatory process. Young children and the aged, bear inflammatory disease poorly as compared to persons of middle life, and those broken down from disease or dissipation do not offer the same resistance as do individuals in robust health.

4. *Accessibility of the Disease to Surgical Treatment.* Suppurative inflammation of the skin can readily be reached and is therefore not as serious as suppurative inflammation in the appendix, and an abscess on the scalp is obviously not attended by the same danger as one located in the brain.

LECTURE XI.

VARIETIES OF INFLAMMATION—CLASSIFICATION. (A) BY CAUSE: MICROBIC—(B) BY DEGREE: ACUTE, SUB-ACUTE, CHRONIC—(C) BY PRODUCT: TRANSUDATE, EXUDATE—(D) BY TISSUE: VASCULAR, NON-VASCULAR.

While all inflammatory processes present the same pathologic changes and the same symptomatic results as described, the process in a given case may be so modified by the character of the cause, by the acuteness or chronicity of the attack, by the product which results, and by the variety of tissue primarily affected, that many types may be distinguished.

A. According to Cause.

The first and most apparent division of the different types of inflammation is based on the character of the cause. Thus the germ of suppuration will produce suppurative inflammation; the germ of erysipelas will produce erysipelatous inflammation; the germ of tuberculosis will produce tuberculous inflammation, etc.

B. According to Degree.

The second division is based on the rapidity with which the inflammatory process develops. If rapid in development and course, it is designated "acute inflammation;" if slow, "sub-acute inflammation;" and if even more tardy, "chronic inflammation." The three types may be due to a modified intensity in action of the same cause or to a difference in resistance on the part of the same tissues. The difference is merely one of degree, and it is often impossible to say in a given case whether a patient has an acute, sub-acute or chronic process. When we contrast the extremes, however, there is a distinct symptomatic and pathologic difference. Acute inflammatory processes are caused by germs of great virulence acting on tissue of low vitality; the symptoms develop rapidly and characteristically, and the condition soon reaches one of its three possible terminations, namely, resolution, suppuration, or gangrene. Chronic inflammatory processes are caused by the action of germs of attenuated power on tissue of good resistance; the symptoms develop slowly, frequently some of them are inconspicuous or absent, and the process is more or less abiding. The most distinctive difference between acute and chronic inflammation, however, is in the source of the new cells which form the inflammatory exudate.

In acute inflammation, the virulence of the toxins elaborated by the microbic cause, produces extensive alteration in the capillary walls and there is the emigration of immense numbers of leucocytes. The formative cells in the perivascular structure are killed and no embryonal cells are formed. Therefore in acute inflammation practically all of the exudate consists in the leucocytes that have escaped from the vessels. In sub-acute inflammation, a condition midway between acute inflammation and chronic inflammation, the poison is of sufficient intensity to cause some alteration in the capillary wall and to permit the escape of a moderate number of leucocytes. It is not sufficiently potent to kill all the formative cells and some are stimulated to increased proliferation. Therefore in sub-acute inflammation, the exudate consists of cells derived both from emigrated leucocytes and from embryonal or granulation tissue.

In chronic inflammation the toxins do not markedly increase the porosity of the capillary walls and but few of the histologic elements of the blood escape. The poisons act principally upon the formative cells. They are not sufficiently powerful to kill them but are sufficiently irritating to stimulate them, and as a result there is rapid proliferation. Therefore in chronic inflammation nearly all of the exudate consists of newly formed embryonal cells.

Chronic inflammation frequently results in the production of an accumulation of embryonal cells, the deposit being technically spoken of as a "granuloma." This is especially true in chronic inflammation of syphilitic, tuberculous or actinomycotic origin.

Often the development of granulomata are so insidious and the local symptoms of inflammation are so inconspicuous that the swellings are mistaken for tumors. Microscopic examination will show, however, the characteristic appearances of inflammation and will demonstrate that the pseudo-tumor is formed of elements derived from the proliferation of the formative cells of the part under stimulation of attenuated toxins, the result of microbic infection. If a granuloma be mistaken for a tumor and carelessly incised there is likely to follow secondary infection with pyogenic organisms and disastrous results to the patient. The proper treatment of granulomata consists in an effort to eliminate or render harmless the primary microbic cause by non-operative treatment. The feeble embryonal cells should not be exposed by an incision to the danger of secondary infection unless the surgeon feels reasonably certain that by an operation he can completely remove the entire inflammatory deposit.

C. According to Products.

A third classification of the different types of inflammation is based on the product or results produced in the tissues involved. Thus, inflammatory action is sometimes followed by saturation of the tissues with fluid, again by infiltration with cells, again by pigmentation with blood, again by the formation of pus, and finally by death of the part.

1. *Transudative Inflammation* is that type of inflammation in which transudation, or the escape of the fluid element of the blood from the vessels, is greatly in excess of exudation or the escape of the corpuscular elements of the blood. This condition usually occurs when the tissues infected are elastic and distensible and do not afford mechanical support to the vessel walls or offer resistance to the percolation of fluid between their fibers. In transudative inflammation there is rapid swelling, the overlying skin becomes thick and glazed and the edematous part becomes "doughy" to the touch and pits on pressure.

2. *Exudative Inflammation* is that type in which exudation or the escape of the corpuscular elements of the blood is in excess of the transudation or escape of the fluid element. This is most

often noted in the compact type of soft tissue, and is generally indicative of an acute well localized inflammatory action such as follows infection with the staphylococci of suppuration. In exudative inflammation swelling is not great, but the part becomes "brawny" and upon palpation a "cake-like" mass can be felt which is sometimes so sharply defined as to feel like a foreign body.

3. *Hemorrhagic inflammation* is that type in which the red blood corpuscles are present in the tissue or in the discharge, in sufficient numbers to give them a reddish tinge. In every case of inflammation a few colored corpuscles escape from the vessels, but it is only under exceptional conditions that their presence can be detected without the use of the miscroscope. When the red blood cells escape sufficiently to cause the case to be classified as hemorrhagic inflammation it is indicative either of infection of the part with germs of great virulence or else of local or constitutional weakness on the part of the patient from age, debilitating disease, or organic affections of the heart, liver or kidneys.

4. *Suppurative Inflammation* is that type in which the exudate and transudate become converted into pus. Owing to the specific action of pyogenic germs, the escaped leucocyte, or the newly formed embryonal cell, is transformed into pus corpuscles and the transudate, fluid or coagulated, changed to pus serum. Often in acute inflammation the infection is primarily with pus germs, but sometimes in chronic inflammation the infection with pyogenic organisms is secondary. As an illustration of the latter may be cited a granuloma produced by the bacillus of tuberculosis, which after months of apparent inactivity suddenly becomes the seat of acute suppurative changes due to secondary infection of the deposit of embryonal cells with pyogenic cocci.

5. *Gangrenous Inflammation* is a result of the inflammatory process in which there is death of the part. This condition may be due either to the intensity of the poison elaborated, or to the arrest of the circulation from pressure on the blood vessels. It is the most malignant type of inflammation and is usually seen in very acute infection of soft structures, such as in a carbuncle,

or may sometimes follow infection of unyielding structures like bone, as in the case of osteomyelitis.

D. According to the Variety of Tissue Affected.

The fourth and last general head under which the types of inflammation are classified is based on the variety of tissue primarily affected. Tissues may be divided into vascular tissues, or those containing blood vessels, and non-vascular tissues, or those containing no or very few blood vessels and are dependent for nutrition upon plasmic streams. Under vascular tissues we consider the following:

1. *Parenchymatous Inflammation* is that type of inflammation in which the parenchyma or essential functionating structure of an organ is primarily involved. Sometimes this results from the direct infection of the cells of the organ, but usually the germs are conveyed to the part through the circulation and effect localization by reason of lowered vitality owing to functional derangement. The cells after infection undergo cloudy swelling and later coagulation necrosis. Illustrations of this type of inflammation are parenchymatous nephritis, and parenchymatous hepatitis, conditions treated more often by the physician than the surgeon.

2. *Interstitial Inflammation* is that type in which the stroma or connective tissue frame-work of an organ is primarily involved. Inflammation of the connective tissue of an organ results in cicatricial contraction and a consequent diminution of the blood supply. As a result the organ becomes smaller, harder and nodular. Examples include interstitial nephritis, interstitial hepatitis, etc. Practically the distinction between parenchymatous and interstitial inflammation is not of great importance since sooner or later, infection of one of these elements will by extension involve the other.

3. *Serous Inflammation* is that in which serous surfaces, such as the peritoneum, pleura, meninges, or synovial membranes, are involved. The peculiar characteristics of this type are that the inflammation tends to remain superficial, that it spreads in a peripheral direction, and that the inflammatory exudates and transudates are poured out on the free surface and retained in

the cavity enclosed by the membrane. When inflammation involves, for example, the peritoneum it may be attended by excessive transudation and the abdominal cavity become distended with fluid, or it may be attended by excessive exudation with the formation of numerous adhesions between the viscera and adjacent structures; or it may terminate by the conversion of the inflammatory product into pus through primary or secondary infection with pyogenic organisms. This explains the production of the three most common types of peritonitis, namely: serous, adhesive and suppurative.

4. *Mucous Inflammation* is that in which mucous surfaces, such as the lining of the respiratory passages, the alimentary canal and the genito-urinary tract, are involved. This type of inflammation possesses the same characteristics noted as peculiar to inflammation of serous surfaces with the exception of the last, namely, retention of inflammatory product in a pre-formed cavity. As all mucous spaces have normal outlets the inflammatory products are not usually retained but escape along with natural secretions or excretions.

The first effect of inflammation on mucosa is to increase its physiological function, manifested by an increased secretion of mucus, as is seen in the early stages of coryza, enteritis or cystitis. If the process stops here it is called catarrhal inflammation. If, however, there is infection with pus germs result'ng in muco-purulent discharge, the process is called suppurative inflammation. If owing to desquamation of superficial cells there is the outpouring of lymph, which by coagulating and entangling cellular débris forms an artificial membrane on the surface, it is called croupous or membranous inflammation.

Having considered the types of inflammation seen in vascular tissue we finally come to consider inflammation as it occurs in non-vascular tissue—say the cornea. It has been stated that the essential features of inflammation consist in the changes that occur in the circulation and blood vessels. Hence, if this be really true, the student will at first wonder how tissues normally non-vascular can present the phenomena of inflammation. It will, however, be seen that the absence of blood vessels in certain tissues and the ability of these tissues to undergo inflammatory changes proves the truth of the proposition. For non-vascular tissues do not present the pathologic changes or the local symptoms of inflammation until they have undergone vascularization. When the cornea is infected there is dilatation of the circle of blood vessels which surround it and from these vessels escapes a certain amount of fluid and cells which render the cornea opaque. Soon new blood vessels can be seen growing from the pre-existing vessels into the previously non-vascular structure. The cornea becomes "blood-shot" or more strictly speaking penetrated with blood vessels. When vascularization is complete, all the characteristic changes of inflammation may be observed. When the process terminates, the blood vessels disappear. If there is resolution there is restoration of normal translucence. If there is suppuration there is substitution of a cicatrix for corneal cells and permanent impairment of vision.

LECTURE XII.

TREATMENT OF INFLAMMATION—ANTISEPTIC VERSUS ANTIPHLOGISTIC METHODS—PROPHYLACTIC AND CURATIVE TREATMENT—LOCAL AND CONSTITUTIONAL MEASURES EMPLOYED, WITH THEIR INDICATIONS AND PRACTICAL APPLICATION.

As long as the phlogistic theory was accepted, inflammation was thought to be due to an increased combustion in the tissues, and was treated by depleting measures, such as starvation, purgation, bleeding and the application of leeches, blisters, cups and caustics. The antiphlogistic treatment of inflammation has now given place to the antiseptic, and we no longer strive solely to combat the results but endeavor to remove the cause. The prophylactic treatment of inflammation by the use of aseptic and antiseptic measures has made possible the achievements of modern surgery. Inflammation which was once universally present in all wounds is now prevented by disinfecting accidental wounds and by avoiding the infection of operative wounds. Despite the universal acceptance of modern surgical technique, cases of inflammation still develop, due either to failure to see the patient early enough or to some defect in the application of recognized principles, hence the necessity of the study of its treatment.

LOCAL TREATMENT.

The local treatment of inflammation consists in the application of remedies to the inflamed area for the purpose of relieving symptoms, such as pain and swelling, and also of correcting the abnormal condition of the circulation and favoring termination by resolution. These measures will be discussed under different heads.

1. *Bleeding.* The withdrawal of a large quantity of blood from the general circulation, or venesection, once the sheet

anchor of the antiphlogistics, has been almost abandoned, as it is now recognized that it not only impairs the patient's resistance but also increases the local congestion by diminishing the *vis a tergo* of the systemic circulation. Scarification, with the direct abstraction of blood from the inflamed area, however, does great good and should be more frequently resorted to than is the practice of the majority of surgeons. Local blood-letting unloads the dilated and engorged capillaries and favors the contraction of the vessels and the re-establishment of the normal circulation. It removes from the tissues a large number of bacteria and eliminates toxic products which would otherwise be absorbed. Finally it relieves tension, thus lessening pain and often averts the danger of gangrene. The best way to accomplish the above results is to disinfect the inflamed area and then make numerous short incisions, the cuts being arranged in parallel lines, those in one line overlapping those in the adjacent line. The flow of blood resulting will usually be copious. If necessary, however, it can by increased by immersing the part in warm sterilized water, or be covering it with a moist antiseptic dressing. The subsequent management of the scarified part should be on general surgical principles.

2. *Counter Irritants.* The seton and moxa once in common use have been completely abandoned. The blister, cautery and iodine preparations are rarely used by the surgeon, although they are still extensively employed by the physician. Counter-irritants applied directly over an inflamed area do not act as derivatives but as irritants, increasing the congestion of the already turgescent blood vessels. If employed at all they should be applied to tissues near by, but not continuous with those primarily diseased. In cases where time is all that is necessary to effect a cure, or in certain chronic conditions, when in the opinion of the surgeon the patient is not in a condition for the application of radical and efficient measures, the judicious painting about the affected part with tincture of iodine will serve the useful purpose of keeping the patient from falling into the care of another practitioner.

3. *Compression.* Gentle, uniform but efficient pressure is a

valuable method of treatment both in the early and late stages of inflammation. In acute cases it restrains the tendency to excessive swelling and prevents the collection of serous or bloody discharges between the lips of the wound. In chronic cases it is one of the best remedies we have to promote absorption and hasten resolution. Compression has to be carefully and properly employed, especially in the early stages, as sloughing or complete gangrene may result from interference with the circulation. It must be remembered that while compression may not be too great at the time it is applied, it may become so later as a result of swelling. Compression may be made in an acute case by enveloping the part in voluminous folds of cotton and utilizing its resiliency by bandaging it tightly with an unyielding binder. Or it may be secured in a chronic case by applying a gauze, flannel or elastic bandage, or by strapping it with adhesive plaster.

4. *Cold.* The sensation of heat imparted by inflammation to both patient and attendant naturally suggests for the treatment the application of cooling remedies. Cold acts beneficially by causing contraction of the dilated blood vessels and to a certain degree by inhibiting the growth of bacteria. It does harm by reducing the vitality of the part. Cold should be employed, therefore, in the early stages of inflammation when there is hyperemia and congestion, and it should not be used in the late stages when there is stasis and threatened gangrene. Cold may be applied either in the wet or dry form. The wet form consists in the constant irrigation of the part with cold solutions, or the application to the part of dressings wrung from ice water, or bathing the affected area with evaporating lotions which have a refrigerant effect. The popular reputations of tincture of arnica, fluid extract of witch hazel and spirits of camphor are not due to any specific medical virtue but to the fact that they all contain alcohol, hence evaporate rapidly and produce cold. Dry cold is applied by means of bottles, bags and bladders filled with water and ice; occasionally by coils of rubber tubing through which cold fluids circulate. In using dry cold care should be taken to prevent freezing the skin.

5. *Heat.* The local application of heat at certain periods of inflammation gives more relief and does more good than any other single agent. Heat acts by soothing the sensory nerves, thus diminishing pain; by drawing blood to the surface, thus acting as a derivative; by favoring the formation of collateral circulation, thus relieving stasis; and by liquefying exudation, and hastening either its absorption or conversion into pus. Heat, like cold, may be employed either in the moist or dry form. The application of moist heat is usually in the form of poultices. These are composed of a great variety of materials, varying from hops, linseed meal and bread and milk to chicken entrails and fresh cow dung. The only virtue of a poultice is heat and moisture, and it is unnecessary to secure these with filth and microbic infection. Moist heat can be most satisfactorily and effectively applied by soaking a thick layer of cotton in a hot antiseptic solution, squeezing it moderately dry, applying it to the part and covering it with some impervious material, such as oil silk or rubber tissue. Owing to the danger of absorption, the antiseptic should not be carbolic acid or bichloride of mercury, but some non-toxic drug such as boric acid, acetate of aluminum or, best of all, chloral hydrate. Dry heat is applied in the form of hot water bags, hot salt bags, beer bottles filled with water, or flat irons, stove-lids, bricks, etc., heated and wrapped in flannel. The frequent occurrence of burns even in our best hospitals, makes it necessary to warn against this danger.

6. *Elevation.* Considerable benefit will result if it is found practicable to keep the inflamed part elevated. Elevation favors the return of venous blood from the part and edematous fluids in obedience to the law of gravity are drawn from the inflamed area, thus diminishing tension and relieving pain. A patient with an inflamed finger soon learns that a dependent position of the hand increases the swelling and pain, and instinctively carries the affected member in an elevated position. This knowledge should be borne in mind by the surgeon and put to practical use.

7. *Physiological Rest.* It is important in the treatment of inflammation to give the part as far as possible mechanical and

functional rest. The mere muscular effort necessary to keep the body erect makes the heart beat fifteen times a minute more than it does when the body is recumbent and relaxed, hence it is frequently advisable to confine the patient to bed in order to diminish the amount of blood going to the inflamed part. Functional activity of an organ increases its blood supply, hence as far as compatible with the life of the individual, the part should be given rest. In arthritis the joint should be immobilized by a splint; in severe gastritis food should be administered solely through the rectum; in retinitis light should be excluded from the room; in acute inflammation of the brain quiet and freedom from excitement should be enforced.

8. *Parenchymatous Injection.* As soon as it was recognized that inflammation was usually due to germs it was believed that the condition might be arrested and the patient cured by the hypodermic injection of solutions containing germicidal drugs. This treatment, while logical in theory, was found almost valueless in practice. All of the efficient chemical antiseptics are poisonous and when used in sufficiently large amount to saturate the tissues they kill not only the germs but the patient. When a reliable non-toxic germicide is found, parenchymatous injections will occupy the foremost place among surgical resources in the treatment of inflammation. At present the method is practically limited to the treatment of carbuncle in the early stages by injecting in and around the infected area a small quantity of 3 per cent aqueous solution of carbolic acid.

9. *Massage.* Rubbing and kneading the tissues do great good in chronic inflammation, but cause too much pain to be employed in acute conditions. They exercise a decided influence in restoring normal circulation, break up inflammatory deposits and hasten their absorption. Frequently the endermic use of certain drugs such as iodide of potassium, mercury and iodoform may be advantageously combined with massage.

10. *Local Hyperemia.* Based upon the fact that the exudate constitutes a part of the inflammatory process as nature's means of combating local infection, August Bier advocates the production of hyperemia as a part of the treatment of acute and chronic

inflammation and suppuration. This in the past has been incompletely accomplished by means of poultices and fomentations. Bier, however, advocates a different principle, namely, the production of passive congestion of the affected tissues. This may be accomplished by moderate elastic constriction placed, in the case of an extremity, on the proximal side of the disease in such a manner as to cause damming back of the blood in the venous radicals leading from the part; or by means of various forms of apparatus upon certain other parts of the body, which when applied, result in the formation of a vacuum like that produced by old-fashioned dry "cups." The latter method is particularly advantageous in that pus and sloughs may be sucked out of a previously opened abscess without the dangers incident to squeezing. A hand or foot may sometimes be placed to advantage in a vacuum box the entrance to which is surrounded by a rubber cloth which when bandaged to the limb prevents air from entering so that the air of the box may be evacuated by a pump. The treatment by hyperemia is of value but it must be clearly appreciated that much depends upon its correct application. Constrictions must be applied with the greatest care, especially in case of severe inflammation where the circulation is already poor, for fear of endangering vitality. A thin rubber bandage may be wound about the extremity well above the inflammatory focus just tightly enough to produce venous congestion without arterial obstruction. Little discomfort should be produced; pain should be relieved by the treatment. Indeed the treatment is applicable only to those cases in which constriction diminishes or relieves pain. Suppuration is generally increased at first, after which it rapidly disappears; in other words the micro-organisms are inhibited and finally destroyed. At the present time the clearest indications for the treatement by hyperemia are found in cases of chronic inflammation when they are tuberculous in nature. It is applicable, however, in acute inflammatory processes either of the soft parts or of bones and joints, and when preceded by incision and drainage, is a useful adjuvant in the treatment of boils, carbuncles and other acute inflammatory processes.

It is necessary for the surgeon to remember that while he endeavors to subdue inflammation by local measures he must at the same time try to improve the patient's general condition by constitutional treatment.

1. *Stimulants.* Weakness due to septic infection, whether it be collapse in acute cases, or exhaustion in chronic ones, calls plainly for the use of an alcoholic stimulant. When the need is urgent, whiskey will be found the most reliable agent and should be given in sufficient dose to produce the desired effect. If the case be a chronic one, the palate and purse of the patient should be consulted, and beer, ale, porter, sherry or champagne sometimes substituted. The action of alcohol on the system is still a question of dispute by theorists but the concensus of opinion of practical men is that it is not only a stimulant but that in disease it lowers fever and lessens oxidization of tissue.

2. *Antipyretics.* Since fever is the result of the introduction of phlogistic substances into the blood the logical way to reduce it is not by the administration of drugs, but by the use of such local measures as will arrest the inflammatory process. Antifebrine, antipyrine, and other similar drugs will reduce temperature if given in sufficient doses, but as a rule they should not be employed, since they are antagonistic to the patient's vitality. If it is found necessary to treat the result rather than the cause, fever should be controlled by baths and sponging with alcohol, which if frequently and properly used will not only reduce the temperature but refresh the patient and increase the eliminative action of the skin.

3. *Purgatives.* Although the routine use of purgation is no longer practiced there are certain conditions in which their proper employment does much good. In inflammatory conditions when vomiting and diarrhea indicate an effort of nature to eliminate poisonous substances through the alimentary canal, relief of the symptoms and benefit will result from the administration of divided doses of calomel. In inflammation of the meninges and of the peritoneum brisk saline cathartics do immediate and decided good.

LECTURE XIII.

SUPPURATION — CAUSES — PATHOLOGY — SYMPTOMS — VARIETY — DIAGNOSIS—PROGNOSIS—TREATMENT—PUS—COMPOSITION — CLINICAL TYPES, ETC.

Suppuration is a process by which the products of inflammation are converted into pus. In all cases of inflammation there is exudation and transudation. In suppuration there is not only exudation and transudation, but the transformation of these products into pus, the exudate being converted into pus corpuscles and the transudate into pus serum.

CAUSES OF SUPPURATION.

Authorities who claim that inflammation is always due to the destructive action of bacteria on tissue are equally insistent that pus can only result from the same cause. While it is true that practically all cases of suppuration which come under the observation of the surgeon are due to infection with pyonic microbes, still, it has been clearly established by many experiments in the laboratory that certain chemical irritants—such as mercury, turpentine, croton oil, etc.—are capable of producing pus in all respects similar to bacterial pus, except that a micro-organism is present in the latter and absent in the former. Furthermore, competent investigators have proved that the toxins of pyogenic bacteria from which the organisms themselves have been removed by filtration or sterilization produce a destructive action on the leucocytes and other cellular elements of the part, by which they are converted into pus corpuscles.

In these experiments chemical products are the source of pus formation. From these and other observations we are warranted in asserting that even in cases where actual infection has been known to precede suppuration the pus microbes are not the direct and immediate causes of pus formation, but act by producing toxins—purely chemical bodies—which are the essential agents in the process.

In previous lectures, it has been maintained that inflammation was caused by irritants, bacterial or otherwise, and it is here held for reasons that have been outlined, that suppuration is also caused by irritants, some of them not of microbic nature. Non-bacterial pus and bacterial pus, while identical in histological structure, differ in their clinical behavior for reasons that will be apparent. Non-bacterial pus is aseptic, does not produce suppuration when inoculated into another animal, and does not tend to become disseminated but remains localized in the tissues. This is due to the fact that the cause of this type of suppuration is a non-vital agent, incapable of self-increase, and having its activity arrested when its chemical affinities are satisfied. Bacterial pus, on the other hand, contains numerous microbes; will reproduce suppuration when inoculated into a second animal, and does not usually remain localized but tends to become disseminated. This is due to the fact that the cause of this type of suppuration is a living organism; and that the power of the germs to increase *in situ*, accounts for its tendency to become progressive. As non-bacterial pus is rarely seen elsewhere than in the laboratory, and hence has only a scientific interest, and as the surgeon in his practical work has to deal with pus resulting from microbic infection, we will proceed to discuss the conditions that predispose to this type of suppuration.

1. *Diminished Vitality of Tissue.* The healthy body resists the invasion of bacteria. The defense is weakened or totally absent if the tissue is injured. The most frequent cause of diminished resistance of tissue is disease such as inflammatory processes, or traumatisms, such as blows or bruises. A mild type of inflammation frequently predisposes to suppuration and a slight injury often results in suppurative disease.

2. *Anatomic Structure of the Part.* Pyogenic germs are almost constantly present in limited number in the circulating blood. Unless they become localized, they produce no trouble. The anatomic structure of certain parts of the body makes these vul-

nerable points for the action of organisms. As illustrations may be mentioned the lymph nodes and the juncture of the shaft and the extremity of the long bones.

3. *The Condition of the Blood.* The life and vitality of the tissues of the body are directly dependent upon the condition of the blood. If this fluid is deficient in any essential element, as in anemia, or if it is impure from constitutional causes, as in diabetes, then the localization of pyogenic germs and the production of suppuration is not only favored but is invited.

4. *The Number of Germs Introduced.* The natural resistance of the body may be able to offer successful defense against a limited number of germs, but is not adequate to resist the invasion of a large dose. Experiments show that the injection of a small number of a certain germ may produce no effect, while the injection of a large quantity of the same culture may cause speedy death.

PATHOLOGY OF SUPPURATION.

When pyogenic organisms effect localization in tissue, they undergo multiplication, elaborate their specific toxins, and produce inflammation. This is attended by the changes described in previous lectures; namely, ischemia, hyperemia, congestion and stasis, accompanied by transudation and exudation. In addition, however, there is the conversion of the inflammatory product into pus. This is accomplished by the liquefying or peptonizing action of the germs or their toxins on the exudate and transudate. The exudate or cellular element is converted into pus corpuscles, and the transudate or fluid element is converted into pus serum. Inflammation is a battle between cells. In suppuration the number of white blood cells throughout the body is actually increased by leucocytosis, and the number of white blood cells in the inflamed part is still further relatively increased by chemotaxis. Therefore, the number of cells in the part is enormously augmented. In the battle, if the cells are victorious, the germs are killed, and they are removed by phagocytosis. If, however, the germs are victorious, then the cells are killed, and their bodies compose the corpuscular element of the resulting pus. In the destruction of a living cell and its conversion into a dead corpuscle, there is, first, intoxication of the cell with the chemical poison elaborated by the germ; then, molecular disintegration of its substance and loss of its outline; and finally, fragmentation of the nucleus.

In the change of coagulated lymph and of liquor sanguinis into pus serum there is liquefaction of the solid element and the formation of a peptone by a fermentative process which renders the resulting fluid incoagulable. Park writes the story as follows: "The leucocytes are the defending army, the vessels its lines of communication, the leucocytes being in effect the standing army maintained by every composite organism. When this body is invaded by bacteria or other irritants, information of the invasion is telegraphed by means of the vaso-motor nerves, and the leucocytes are pushed to the front, reinforcements being rapidly furnished so that the standing army of white corpuscles may be increased to thirty or forty times the normal standard. In this battle, cells die and are often eaten by their companions. Frequently the slaughter is so great that the tissues become burdened by the dead bodies of the soldiers in the form of pus, the activity of the cells being proved by the fact that their protoplasm often contains bacilli in various stages of destruction. These dead cells, like the corpses of soldiers who fall in battle, later become hurtful to the organism which, during their lives, it was their duty to protect for they are fertile sources of septicemia and pyemia."

DESCRIPTION OF PUS.

Pus is the liquefied material which forms as the result of suppurative inflammation. In inflammation due to infection with pyogenic organisms, the continued and increasing action of the irritant causes the escape of an excessive amount of exudate, the polymorpho-nuclear leucocyte being the principal element. The action of the toxins present in the tissue converts the leucocytes into pus corpuscles, causes degeneration of the fixed tissue elements and leads to liquefaction of the inter-cellular substance, until finally the whole area undergoes necrosis. Senn described pus as dead or dying tissue composed of cells with a fluid inter-cellular substance. Pyogenic germs when grown on beef gelatine cause liquefaction of the culture medium by virtue of their peptonizing action due to the liberation of a ferment. It is in consequence of the same peptonizing action that the inflammatory products are converted into a fluid or pus.

Pus is a yellowish white substance, the consistency of cream. It is usually odorless and has an alkaline or faintly acid reaction. Its specific gravity is about 1032. It is composed essentially of two elements, the fluid portion and the cellular portion.

(1) *The Fluid Portion of Pus, or Liquor Puris,* is derived either from the blood serum or from the liquefied inter-cellular substance of the tissue. It is a transparent, pale greenish fluid and contains soluble compounds, the result of the inflammatory process, such as peptones, toxins, etc.

(2) *The Cellular Portion of Pus, or Pus Corpuscles,* are derived from two sources, viz: from the emigrated leucocytes and from the embryonal cells of the inflamed area. Pus corpuscles are therefore the bodies of dead cells. They are usually round, but sometimes are fantastic in shape. They are composed of granular protoplasm and contain apparently sometimes as many as fifteen or twenty nuclei, due to disintegration of the protoplasm and nucleus of the cell. If subjected to the action of acetic acid, pus corpuscles become clear and show their fragmented nuclei more plainly. If placed in water, they become larger and swollen from absorption of fluid. If treated with liquor potassa, they are dissolved and changed into a gelatinous mass.

CLINICAL VARIETIES OF PUS.

1. *Laudable pus* is thick creamy pus, without odor or irritating properties and soon disappears leaving healthy granulations.
2. *Sanious pus* is pus mixed with blood. It is usually irritating and is indicative of a serious type of infection.
3. *Ichorous pus* is pus undergoing decomposition. The pus cells are few in number and the fluid is thin and acrid.
4. *Fetid pus* is pus that stinks. It is due to a special pyogenic germ and is usually found in the region of the anus and

genitalia and in abscesses about the appendix or some other portion of the alimentary tract, the kidneys or from the middle ear.

5. *Chromatic pus* has a brilliant color. Sometimes it is blue, sometimes red, the hue being diagnostic in each instance of infection with a certain organism.

6. *Serous pus* is mixed with serum. Its presence indicates the infection of a serous cavity.

7. *Mucous pus* is pus mixed with mucus. Its presence indicates infection of mucous membrane.

8. *Inspissated pus* is pus which has become encapsulated, the pyogenic germs exterminated and the fluid element removed by absorption.

SYMPTOMS OF SUPPURATION.

The symptoms of suppuration vary so greatly with the locality infected and the variety of the pyogenic organisms introduced that the subject cannot be satisfactorily discussed in general terms, but must be taken up in detail in succeeding lectures under the different structures of the body and the different types of pus-producing germs. It may be broadly stated, however, that the constitutional symptoms consist of fever usually preceded by sensations of chilliness or an actual rigor. The local symptoms commonly embrace swelling of the part which becomes tense and brawny and is colored by a crimson blush. Pain is acute and throbbing, and the part is hot. As pus approaches the surface, the tissues near the center of the inflamed area become softer and finally fluctuation may be demonstrated. The pressure on the overlying skin causes it to become thin and white, and "pointing" is said to have occurred. Finally, there is rupture, and spontaneous escape of the pent-up pus. When this occurs, all symptoms at once begin to subside.

VARIETIES OF SUPPURATION.

Suppuration is divided into acute, sub-acute and chronic suppuration, according to the time required for the process to convert inflammatory products into pus.

1. *Acute Suppuration* is caused by germs of great virulence introduced in large numbers. The symptoms come on sharply and the process reaches its climax quickly. In this type, the pus corpuscles are derived exclusively from the leucocytes, as there is not time for embryonal cells to develop.

2. *Sub-acute Suppuration* is caused by infection with germs of less qualitative or quantitative power than the above. The symptoms develop more slowly and last for a longer time. In this type, pus corpuscles are derived from both leucocytes and embryonal cells, as both constitute an element in the exudate.

3. *Chronic Suppuration* is caused by infection with germs of mild or attenuated virulency. The symptoms develop slowly and are persistent. In this type, the pus corpuscles are formed almost exclusively from embryonal cells of granulation tissue

DIAGNOSIS OF SUPPURATION.

The diagnosis of suppuration is easy when the location of the inflamed area is such as to render the local symptoms obvious. When the process is deep seated, the diagnosis is often difficult and can sometimes only be made by a careful study of the temperature chart, a count of the white blood cells to determine the presence or absence of leucocytosis, and occasionally by the use of the aspirator.

PROGNOSIS OF SUPPURATION.

The prognosis of suppuration depends upon many factors, such as the character of infection, the location of the process, the general condition of the patient, the ability of the surgeon, and the facilities at hand in the nature of instruments, dressings, assistants, etc.

TREATMENT OF SUPPURATION.

The reasons given under a previous heading make it impossible to discuss the treatment of suppuration, whatever its form or wherever it occurs, in general terms. The type and location so modify the indications that they must be taken up later in detail. Here all that can be said is that in every case of suppuration the following practice may be followed with advantage:

1. Incision, early and free, to relieve tension and prevent further extension.

2. Irrigation, to mechanically remove offending material and prevent absorption.

3. Disinfection, to destroy accessible micro-organisms, to limit further destruction and to prevent the danger of subsequent putrefaction.

4. Drainage, to remove either by gravity, suction or capillarity the pus that forms after evacuation and before complete sterilization.

5. Hyperemia of the passive variety according to the technique of Bier as previously described is useful as a supplemental measure.

LECTURE XIV.

ABSCESS—ACUTE AND CHRONIC—ETIOLOGY, PATHOLOGY, DIAGNOSIS, PROGNOSIS AND TREATMENT—PHLEGMONOUS INFLAMMATION WITH SUPPURATION—VARIETIES, CAUSES, PATHOLOGY, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT.

From the standpoint of the practical surgeon suppurative processes may be roughly divided into two classes, those that tend to remain local, or abscesses, and those that tend to spread, or phlegmonous inflammation.

Abscess. An abscess may be defined as a circumscribed collection of pus in tissue. An accumulation of pus in a preformed space is not an abscess, and to impress this distinction such cases are designated by the term *pyo-*, to which is added the anatomical name of the locality involved. For example, pus in the pleura is called pyo-thorax; pus in the pericardium, pyo-pericardium; pus in the Fallopian tubes, pyo-salpinx; pus in the kidney, pyonephritis, etc. The characteristic tendency of suppuration is towards extension and the involvement of adjacent tissue. When the process is limited and an abscess results, it is proof of the action of nature's protective influence. Any doubt of this benign view of abscess formation will be satisfied when we pass to the description of the practically unresisted activity of germ life as seen in phlegmonous inflammation. Abscesses are divided for study into acute or hot abscess, and chronic or cold abscess.

An *Acute Abscess* is a circumscribed collection of pus which is rapid in its development and attended by well marked local and constitutional symptoms.

The *Predisposing Causes* are the same as those of suppuration. Broadly speaking they are conditions which lower the vitality of tissue. They may be classified as, first, local injuries—such as contusions or sprains so insignificant as to pass unnoticed, except by the ever watchful microbe—and, second, general debility—from age, starvation, intemperance, anemia and numerous other factors. Both act by disarranging the nicely adjusted balance existing between immunity and predisposition to infection.

The *Exciting Cause* is the germ of suppuration. Usually the staphylococcus will be found in the pus, the streptococcus being generally associated with a more progressive type of infection. Yet all the bacteria designated as pyogenic and some of those commonly classed as non-pyogenic, singly or combined, may be responsible for the production of an abscess. The microbe sometimes enters the tissue directly by means of an infection atrium, or again, indirectly by means of the circulation.

Pathology. As soon as the germs effect entrance and undergo localization they rapidly multiply, elaborate toxins and produce inflammation. This is attended by the characteristic changes in the histologic elements of the part described in a previous lecture under hyperemia, congestion and stasis. Emigrated leucocytes and newly formed embryonal cells pack the spaces between pre-existing tissue elements, and transudated serum adds to the tension of the part. The circulation is impaired and necrosis results from poison and pressure. The cellular elements in the part are converted into pus corpuscles and the fibrin and intercellular substances are liquefied by the peptonizing action of the toxins and changed to pus serum. The result is the formation of pus. While these changes are taking place in the center of the inflamed area, the outer zones are in a condition of hyperemia and the formative cells are in a state of active proliferation. The leucocytes beyond the area of infection are not converted into pus cells, and they, together with the newly formed cells, form a wall beyond which the infection does not pass. Clinically we recognize this so-called abscess wall by its induration or hardness. Intermediate between the center of necrosis and liquefaction on the one hand and the wall of aseptic infiltration on the other, there lies a zone of varying appearance. Near the center there is found necrotic tissue, rich in leucocytes; external to this exudative fluids and numerous leucocytes:

beyond this, proliferating fixed connective tissue cells entangled in fibrin, and finally a gradual shading off into the wall already described.

The old authorities believed that the abscess wall secreted the pus it circumscribed and called it the pyogenic membrane. It is hoped that it has been made plain to the student that it is not a pus producing membrane, but a pus retaining barrier. It is the result of the conservative effort of the system to protect itself from the further advance of pyogenic infection.

An abscess tends to increase in size, and this is accomplished by disintegration of the inner zone and a gradual involvement of new tissue by the outer circle. Infection spreads in the direction of least resistance, and this is usually toward the surface of the body; in other words, to the skin or mucosa. Owing to this fact is due the tendency of an abscess to undergo what is called "pointing," a fortunate provision of nature, by which poisonous material is given a safe exit from the system.

When pus approaches the surface a red, indurated spot is noted on the skin. This spot becomes elevated into a cone, which softens until fluctuation can be demonstrated, and the epithelial covering becomes thinned by pressure until it is transparent. Finally, ulceration creates an opening and the contents of the abscess are discharged. As soon as tension is relieved there is a copious flow of serum from the congested tissue into the abscess cavity. This results in flushing it out and favors the action of the protective forces, the phagocytes, the antitoxic and antibacterial bodies present. When the infective organisms are destroyed or rendered inert, liquefaction and pus formation cease, the abscess walls collapse and reparative efforts assume the ascendency.

Symptoms. The constitutional symptoms of abscess formation are usually a more or less well-marked rigor followed by a rise of temperature. They vary greatly in intensity and depend on the character of infection, the size of the abscess, the density of overlying structures and the time of its evacuation. The local symptoms are pain, heat, swelling, redness, tenderness and fluctuation. If a so-called stitch-hole abscess develops, the patient will, a day or two after the operation, lose appetite, become restless, suffer with headache, and complain of feeling chilly and hot by turns. There will be throbbing, lancinating or aching pain in the wound. There is leucocytosis and iodophilia. On examination there will be found redness and swelling, the part feels hot and is very tender to pressure. Soon fluctuation can be demonstrated, pus approaches the surface, and finally by the process of pointing an exit is given for its escape.

Diagnosis. The diagnosis of an acute abscess is usually easy. The history of infection, the rigor and fever, the pain, heat and redness, and finally, the development of fluctuation, makes an unmistakable picture. Deeply seated abscesses sometimes lack several of the classical symptoms. Heat, redness and fluctuation may be inconspicuous, or absent, and local edema, a drawing feeling or only muscular rigidity point to the necessity of an exploratory incision. An aneurism, especially in the neck, has been mistaken for abscess, the absence of fluctuation being considered due to the tension of the deep fascia and the presence of pulsation attributed to the transmission of the propulsive force of neighboring vessels. Sometimes rapidly growing, malignant tumors simulate abscess formation, the softness of the mass imparting the sensation of fluctuation to the palpating finger and the increased amount of blood in the part giving rise to redness and increase of local temperature. In all doubtful cases a white blood count should be made to determine if leucocytosis be present. The use of an aspirator so frequently employed by some surgeons is to be condemned. It is not free from danger to important structures and frequently leads to false conclusions, owing to the needle becoming clogged and failing to evacuate the pus. When uncertain, and the symptoms are urgent an exploratory incision should be made. This procedure is usually effected by making a cut half an inch in length through the skin and fascia, then laying aside the knife and taking a pair of blunt hemostats and boring through the tissue in the direction of the supposed pus collection. If one be reached it will be recognized by the sudden loss of resistance and by the escape of the characteristic fluid along the blades of the instrument.

Prognosis. This is based upon the general health and vitality of the patient and upon the size and location of the abscess.

Treatment. The dictum of the old surgeons, *ubi pus, ibi evacuo* is as true today as when it was written. An abscess should be evacuated as soon as it can be located. Modern methods enable the surgeon to do this without danger of additional infection. Nothing is so dangerous as delay. Better open too soon than too late. If the incision is made before pus actually forms, it may, by relief of tension, and removal of toxic fluids, prevent its development. On the other hand, delay in affording operative relief may cause extensive injury to adjacent tissue. For example, an abscess of the appendix may rupture and cause diffuse peritonitis; a deep-seated cervical abscess may burrow under the fascia with disastrous consequences. A neglected peri-rectal abscess may fill the ischio-rectal fossa, open both into the rectum and on the skin, and cause a fistula in ano.

An abscess should be opened so as to perfectly empty it and prevent any reaccumulation of pus. It is rarely necessary to make an incision over an inch in length. If the abscess is large and its location favorable it is often wise to make a counter opening to facilitate drainage. The first incision should be made at the point where fluctuation is greatest, i. e., where the pus is nearest the surface. After incising the skin and fascia take a pair of hemostats and tunnel intervening tissue until lack of resistance indicates entrance to a cavity. To make a counter opening, carry the closed forceps across the cavity and push it from within outward to an opposite point, where dependent drainage will be best secured. Then incise the skin over the point of the forceps, push them through and dilate the opening thus made by separating the blades. To drain the cavity, place the end of a fenestrated rubber tube of proper size in the jaws of the forceps as they project through the counter opening, clamp the forceps and draw the tube through the cavity by withdrawing the forceps. By this maneuver one end of the tube projects through either opening and the whole width of the cavity is drained. Before placing the drainage, however, it is well in many cases to curette all necrotic tissue from the walls of the abscess with a sharp spoon, and to irrigate the cavity with some antiseptic solution. Dressings should be changed daily and, if necessary, irrigation repeated. When suppuration almost ceases the tube should be removed. Rest in bed is essential in the treatment of a large abscess. If the abscess be in a limb the use of a padded splint may be sufficient.

A Chronic or Cold Abscess is a circumscribed collection of fluid which is slow in its development and often unattended by well marked local or constitutional symptoms. The fluid is frequently not pus but an emulsion of broken down tissue which looks like pus. In this case the condition is not strictly speaking an abscess.

Chronic inflammation, such as is produced by tuberculosis, actinomycosis, syphilis and similar diseases results in the formation of a large number of embryonal or granulation cells. When aggregated together they are known as granulomata. They have little vitality and readily undergo coagulation necrosis and disintegration. The cellular elements become suspended in serum from the blood and the product closely resembles pus. Since the infection which produces the condition is tubercular, actinomycotic or syphilitic, and not pyogenic, and since the result is the formation of an emulsion of broken down tissue in serum, and not pus, the so-called "cold abscess" is technically not an abscess at all. The subject of chronic or cold abscess will be fully treated under the head of tuberculosis. It has been mentioned at this time to call attention to the misuse of a term which must be continued in deference to custom.

Of course it must be remembered that any granuloma may become secondarily infected with pyogenic cocci and as a result be converted into a true abscess. Should this occur, the pathology, symptomatology and treatment will be the same as those previously described.

Phlegmonous Inflammation with Suppuration. In abscess formation nature asserts its defensive power and a limiting wall is formed beyond which suppuration cannot go. In phlegmonous inflammation with suppuration, the system is unable to withstand the virulency of the infection, and there is a rapidly spreading inflammation accompanied by suppuration, which shows no tendency to become localized.

Graver degrees of phlegmonous inflammation are described under the names of diffuse suppurative inflammation, progressive purulent infiltration, and the purulent edema of Pirogoff. These represent the last extremes to which virulence of infection, coupled with abeyance of the resistance of the system, may carry the individual. They are, however, but more advanced degrees of diffuse phlegmonous inflammation and will be discussed as such.

Cause. Diffuse suppuration is especially prone to follow compound fracture of bones of the extremities, and railroad and other crushing accidents attended by extensive contusions and laceration of the connective tissue. In such accidents the tissues are not only devitalized by the crushing force, but often all forms of contaminating dirt are ground into them, thus bringing into intimate association the two prime factors of suppuration—devitalization and infection. Still, such grave consequences may follow insignificant lesions, such as a neglected wound or punctured injury. The germ most frequently cultivated from the pus of these cases is the streptococcus pyogenes, although often the staphylococcus pyogenes and the streptococcus erysipelatus are found in conjunction with it.

Pathology. Phlegmonous inflammation with suppuration primarily affects the connective tissue and its line of extension follows it. As connective tissue surrounds and binds together all the structures which compose the extremities, the destruction of connective tissue results in detachment of the skin over wide areas and the separation of muscles, nerves and vessels as if they had been dissected for anatomical demonstration. The marked and characteristic peculiarity of the process is the propensity of the pus to burrow, spread and become disseminated.

Symptoms. If phlegmonous inflammation with suppuration follows a crushing injury, usually three or four days elapse before the first evidence of the infection. The first symptom is a chill or succession of chills, followed by rapid pulse and high fever, which terminates in copious sweats. Examination of the wound shows a sanious discharge accompanied by local redness and a rapidly spreading edema. Death may shortly ensue. If life be prolonged pus formation is inevitable. The constitutional depression is marked from the onset because pyogenic germs have invaded an extensive area, are reproduced with astonishing rapidity, and gain access to the general circulation at an early period. The soft structures, injured by traumatism and devitalized by poison, become saturated with bloody serum and make a most fertile soil for secondary infection with putrefactive bacteria.

Diagnosis. The history of infection, the chill, fever, sweat and prostration; the sanious discharge, angry wound and local edema leave no doubt as to the nature of the condition.

Prognosis. The disease is a grave one; life and limb hang in the balance. The tissue will depend upon the amount of infection and the quickness and thoroughness of the surgeon's operative intervention.

Treatment. As already indicated, no temporizing measures give promise of success. Treatment must be prompt and heroic. To illustrate the methods to be employed we will take a case of phlegmonous inflammation following a compound fracture.

1. *Disinfection, Incision and Drainage.* Administer a general anesthetic and disinfect the surface of the limb as for a major operation. Apply an elastic constrictor above the area involved to prevent bleeding. Open the wound, remove blood clots, cut away all fragments of necrotic tissue, freely expose and turn out the ends of the broken bone. Curette the infected medullary cavities and open pus sinuses or pockets. Fill the wound with a solution of peroxide of hydrogen, then irrigate with 1-1000 bichloride solution and finally wash it out with saline solution. The elastic constrictor is now removed and bleeding points ligated with catgut. Bountiful provision must be made for drainage. To do this, openings and counter openings should be placed so as to give every portion of the diseased area "down hill" drainage. Through these openings fenestrated rubber tubes are placed. Finally the ends of the bones should be placed in approximation, a copious, hot, moist, antiseptic dressing applied, the limb immobilized and the patient put to bed.

2. *Continuous Irrigation.* If within six hours the pulse, temperature and other symptoms do not show improvement, it may be logically assumed that the septic process is still active. The indication is now to remove the dressings, to protect the bed with a rubber sheet and to resort to continuous irrigation of the wound with warm, non-toxic, but reliable antiseptic solution. By this means, wound secretion is washed away, accumulation of pus is prevented, toxins are removed before they can be absorbed, and the tissues are kept saturated with a solution that at least inhibits the growth of microbe life. The solutions used are chlo ral hydrate (1 to 2 per cent), acetate aluminum (1 per cent), boric acid (2 per cent), or tincture of iodine (enough to give water the color of sherry wine). The solution selected is poured into a water cooler which has been properly disinfected. The receptacle is placed slightly above the level of the bed; one end of a rubber tube is connected to the faucet, and the other end is carried to the wound. By turning the stop-cock the flow can be regulated. The mackintosh on the bed is arranged so as to drain into a bucket on the floor.

3. *Amputation.* If the foregoing treatment fails then an amputation must be considered as a last and desperate resort to save life. There is no means of knowing when a fatal dose of septic poison has been absorbed, and hence if the patient's strength permits, a mutilating operation is justifiable to prevent the introduction of additional toxins. If such a course is elected the amputation should be done high enough to secure healthy flaps. There is no line of demarcation between healthy and infected tissue. The jeopardy of the patient's life outweighs all other considerations. The limb must be sacrificed to save life and the operation should be quickly performed.

LECTURE XV.

PALMAR ABSCESS—SUPPURATIVE TENOSYNOVITIS—PARONYCHIA—FURUNCLE—CARBUNCLE.

PALMAR ABSCESS.

A palmar abscess is an abscess of the palm of the hand, usually originating from punctural wounds or abrasions. It may be superficial or deep, the first being above and the second below the palmar fascia.

Causes. The essential cause is one of the germs of suppuration. The predisposing cause is a fissure or blister giving entrance to the infection, and a bruise or other local trauma lessening resistance and enabling the microbe to effect localization and produce suppuration.

Symptoms. A superficial palmar abscess amounts to little more than an ordinary boil and presents merely the symptoms of pain, heat, redness and swelling, followed by softening, liquefaction and pointing. A deep palmar abscess is a more serious condition, as the pus is prevented from approaching the surface and burrows along the sheaths of the tendons and may even find its way between the metacarpal bones to the back of the hand. Pain, owing to the tension, is exquisite. Swelling and redness are not marked until the later stages. The fingers are often flexed and the hand assumes a claw-like aspect.

Treatment. Here, as elsewhere in suppurative processes, the treatment consists in incision and drainage. The practitioner for fear of injuring the palmar arch frequently makes an inefficient puncture and fails to give relief. If after placing the hand in the anatomical position, a line is drawn across the palm at the level of the fold of skin where the thumb joins the hand, and the incision is made below this line there is no danger of cutting the arteries. The abscess should be opened by an incision parallel with the axis of the fingers and in bad cases one or more counter openings made and drainage effected by tunneling between them and carrying a fenestrated tube from one opening to another. Such cases should subsequently be treated with moist antiseptic dressings and elevation of the part.

SUPPURATIVE TENOSYNOVITIS.

Suppurative tenosynovitis is a suppurative inflammation attacking a tendon sheath. It is especially frequent in the fingers, hand and forearm.

Causes. It is due to pyogenic infection, which may result directly from an infected wound, or secondarily from a bone felon or other focus of inflammation.

Symptoms. The condition is attended by severe pain, by heat and redness, and by swelling, which extends in the direction of the tendon. Unless prompt relief is afforded, necrosis may result from pressure and poison and the tendon be destroyed. Not infrequently a neighboring joint may be involved.

Treatment. The tendon sheath should be opened by a free incision. After the pus escapes a curved forceps should be passed to the upper and lower limits of the cavity and other incisions made so that a drainage tube may be drawn from one end to the other of the infected area. Through this tube, irrigation should be practiced until suppuration ceases.

PARONYCHIA.

Paronychia, whitlow and bone felon are synonymous terms applied to suppurative inflammation of the fingers. They should all be discarded, as they do not all indicate the anatomical or pathological features of the condition. Paronychia is nothing but an abscess of the finger and may be superficial or deep.

Causes. The essential cause is the pus germ. It may follow infection from a simple scratch or hang nail, but usually results from traumatism. It is often seen in carpenters, owing to the injuries received in doing rough work, and in surgeons, owing to infection incident to doing dirty work. In fact, before the days of asepsis, operators were so often the victim of the condition that it was merely necessary to say a man had a septic finger to understand the nature of the disability.

Symptoms. The abscess may be superficial and cause but short or slight disability; again it may be deep and cause great and prolonged suffering and result in death of bone and permanent deformity. The inflammation usually begins on the palmar aspect of the last phalanx or around the base of the nail. The finger soon becomes hot, red, tense, and the seat of throbbing pain. Owing to the compactness of the tissue there is but little swelling. Discomfort is aggravated by the pendent position and relieved by elevation.

Prognosis. As indicated, the trouble may be but a trivial affair and again it may disable the patient for months and leave him with a permanent deformity. The complications to be guarded against are suppurative periostitis, osteomyelitis and arthritis.

The prevention of a bone felon consists in the proper care of the hands and should especially be observed by the surgeon. The nails should be kept in good condition and the disinfectants employed before the operation for the safety of the patient should be practiced after the operation for the safety of the surgeon. When the condition actually develops abortive treatment is almost worthless, the only two agents of any service being elevation and the local application of cold. The induction of Bier's hyperemia is in many cases useful but not yet thoroughly standardized. As soon as it is obvious that pus exists, the part should be carefully disinfected, anesthetized either by the hypodermic injection or a solution of cocaine or by freezing with chloride of ethyl, an incision should then be carefully and deliberately made in the long axis of the finger passing through the various structures until the pus is finally reached. The hand should be given a prolonged bath in a hot antiseptic solution to promote bleeding and thus relieve tension and remove local sepsis. It should afterwards be dressed with a moist antiseptic compress.

FURUNCLE.

A furuncle, or boil, is an abscess of the skin or a circumscribed collection of pus in cutaneous or subcutaneous tissue resulting from infection of a hair follicle. When there are many furuncles on the same patient, the condition is spoken of as furunculosis. A furuncle is usually an insignificant lesion, but it sometimes results in phlebitis, suppurative osteomyelitis, or pyemia, and should not be treated lightly.

Cause. The pyogenic germ usually responsible, is the staphylococcus pyogenes aureus. Other germs, however, are sometimes associated with it. The predisposing factors are many and often obscure; by some they are considered of great importance, by others they are ignored. It is a fact that boils occur frequently in patients suffering with diabetes, anemia, asthenia, marasmus, and malnutrition, but it is equally true that they also occur in the healthiest and sturdiest individuals.

Symptoms. The first symptom is usually itching followed by the development of a red papule which becomes hard and painful. Often, if a careful examination is made at this stage it will be seen that in the center of the inflamed area there is a hair follicle, indicating that the germs have passed from the superficial to the deep layer of the skin along the hair. The swelling and redness increase and the condition justifies the old saying "as sore as a boil." A cone-shaped elevation forms, liquefaction in the center takes place, pus approaches the surface and a yellow point appears, spontaneous opening occurs, and there is the escape of thick, yellow pus. On examination of the interior of the cavity a tough white or gray slough is seen, commonly called the core. This is nothing but connective tissue of the part, which has been killed but not liquefied. As soon as the core separates and is expelled, the surface of the cavity clears off and becomes covered by healthy granulations and rapidly closes.

Treatment. The old idea was that boils were due to impure blood, and hence the treatment was by blood purifiers. The modern idea is that boils are due to unclean skin, and hence great importance is attached to external cleanliness and disinfection. In a person who is predisposed to the development of boils, the skin should be kept clean by baths and disinfectants and the most trifling abrasion should receive prompt attention. It is also equally important to see that the linen or flannel underwear, which has been infected, be boiled before being again worn. The patient's general health should be investigated and such dietetic, hematic and tonic treatment should be instituted as seems indicated. When a boil begins it may sometimes be aborted by the extraction of the hair through whose follicle the infection has entered and by application to the spot of a small drop of pure carbolic acid. When pus actually forms, however, it should be evacuated and the necrotic tissue, or core, which accompanies it, removed and the resulting cavity disinfected. The operation is a minor one, but should be done under antiseptic precautions. The part affected should be shaved, washed, and disinfected. The skin should be anesthetized by the injection of cocaine or by freezing with chloride of ethyl. A small crucial incision should be made over the center of the focus with a sharp, clean knife, and the cavity cleaned out with a curette. It should then be sponged with a bit of cotton wet with bichloride or carbolic solution, packed with a small strip of gauze and protected by an aseptic dressing. The dressing should be removed and the packing taken out and replaced as frequently as indicated.

CARBUNCLE.

A carbuncle is described by Senn as a collection of furuncles. It is made up of a number of foci of suppuration, which develop simultaneously or in rapid succession and usually become confluent. It is characterized by dense induration and by sloughing. It invariably shows several openings on the skin through which pus escapes. It varies in size from that of a silver quarter dollar to that of a soup plate. It most commonly develops on the back of the neck, but may be found elsewhere. It is most common in individuals between the ages of forty and sixty years old.

Cause. The staphylococcus pyogenes aureus and albus are usually the germs responsible. They may be inoculated by the finger nail or by small injuries such as may be inflicted by a rough collar. It is often associated with diabetes, anemia and other debilitating constitutional conditions.

Symptoms. Usually before the actual manifestations of infection develop there is a general feeling of malaise, followed by a chill and fever; then comes a stinging, burning pain at the site of the future lesion; the skin becomes red, indurated, and painful. A swelling forms with a broad flat base and an oval surface considerably raised above the level of the skin. The outline is usually circular, although it may be irregular; ulceration occurs at several points and openings result through which pus escapes. This gives a cribriform appearance. Sloughing of intervening tissue takes place and through the enlarged openings it is seen that the deeper tissue is involved. Sloughing continues, and finally an open crater forms with fibrous septa. Constitutional symptoms are always present in greater or less degree, due to the absorption of pus and the products of tissue necrosis.

Diagnosis. Furuncle and carbuncle have one essential difference, namely, that a furuncle originates from one focus of infection and discharges through one opening, while a carbuncle originates from a number of foci and discharges through an equivalent number of openings. The difference of induration, of depth, of extension, and of constitutional symptoms are merely differences of degree.

Prognosis. The prognosis depends upon the age and general health of the individual, upon the size and location of the lesion, upon the intensity of the constitutional symptoms, and upon the courage and ability of the surgeon.

Treatment. Many local applications have been advocated, but none are positively curative. Heat and cold serve to relieve the pain and may be employed in the form of a hot fomentation or an ice bag. If the carbuncle be a small one and is seen early, it may sometimes be cured by the hypodermic injection of a 3 per cent solution of carbolic acid in water, the needle punctures being made beyond the zone of inflammation and the fluid so injected as to saturate the diseased tissue. In this method care should be taken not to inject a dose of carbolic acid which could cause a patient serious constitutional symptoms. Wood suggests injecting pure carbolic acid through the several openings of the carbuncle in order to disinfect and destroy the tissue involved. If successful a slough forms in a few days; when it separates it leaves an ulcer, which soon contracts and cicatrizes. As a general rule, however, the non-operative treatment of carbuncle is ineffective and the patient will be saved much time and unnecessary suffering by the use of the knife.

There are two methods of operating, as follows:

1. *Incision.* This consists in exposing the infected tissue by making a crucial incision through the overlying skin and reflecting the flaps. The suppurative gangrenous material is removed with a sharp curette and the surface disinfected by either the application of chloride of zinc, carbolic acid, or an actual cautery. The resulting cavity is loosely packed with iodoform gauze and the flaps put back in the position they formerly occupied. The packing is removed and replaced at necessary intervals until the wound becomes healthy. This is no doubt hastened by Bier's method of suction by cups.

2. *Excision* consists in the bodily removal of the carbuncle as if it were a malignant tumor. A circular incision is made around the infected area and deepened through healthy structures until a plane is reached below the depth of suppurative inflammation. The mass is then removed in one piece and the resulting cavity allowed to fill by granulation under a moist antiseptic dressing.

The general treatment of carbuncle embraces the use of stimulants and tonics, such as whiskey and strychnina, quinine and iron, the careful regulation of the diet in order that it may be nutritious, but easily digested, and a search for and correction of complications, such as nephritis or diabetes.

LECTURE XVI.

ABSCESS OF THE MAXILLARY ANTRUM, LIVER, BREAST, LUNG, AND BRAIN.

ABSCESS OF THE MAXILLARY ANTRUM.

An abscess of the maxillary antrum is a collection of pus in the antrum of Highmore. According to the definition of abscess already given, the term is not a correct one, as it is a collection of pus in a pre-formed space, and should, strictly speaking, be known as pyo-antrum. It is retained, however, in deference to custom.

Causes. The antrum of Highmore communicates by an opening into the nose and is frequently perforated on its floor by the roots of one or more teeth. Infection usually reaches the cavity through the nose or by way of the root of a tooth.

Symptoms. When pyogenic organisms effect localization and produce suppuration, there is pain, which radiates in the direction of the facial nerves, swelling of the overlying soft structures from inflammatory edema, tenderness over one side of the face, and sometimes because of rarefaction of bone, crepitation may be elicited by pressure.

Diagnosis. Percussion over the collection of pus will give dullness. If a small electric lamp is placed in the mouth, while the patient is in a dark room, an area of light will be seen beneath the eye on the sound side, whereas it will be absent on the side containing pus. Sometimes if the opening between the nose and the antrum is patulous, pus may flow from the antrum into the nose when the head is turned to the opposite side. This sign is pathognomonic.

Treatment. The indications for treatment are evacuation of the pus and the establishment of free drainage. The old way to accomplish this was to extract the first bicuspid tooth and perforate the antrum through its socket. If the tooth be healthy, however, its sacrifice is unwarranted. Equally good results can be secured by incising the mucosa one-half inch above the tooth and perforating the bone with a drill. After emptying the cavity it should be irrigated with an antiseptic solution and a drain inserted. If the condition is found to be a bad one, a counter-opening may be made through the nose and a fenestrated tube inserted so as to pass through the cavity. The tube should be kept in place until suppuration ceases.

ABSCESS OF THE LIVER.

Abscess of liver is a collection of pus in hepatic tissue.

Causes. Predisposing causes are exposure, alcoholism, and residence in tropical climates. The direct causes are infection with either the ordinary staphylococcus pyogenes aureus, the ordinary colon bacillus, or the amebæ coli, the latter being the peculiar organism of amebic or tropical dysentery. Either of these may reach the liver by way of the portal system, and it is a fact that most cases of hepatic abscess are secondary to gastric ulcers, appendicitis, dysentery, cholecystitis, or suppurating hemorrhoids. When due to infection with the common staphylococcus, or the colon bacillus, liver abscesses are usually multiple. When due to the amebæ coli they are usually single.

Symptoms. The symptoms of abscess of the liver are often vague. At times they point definitely to the liver as being the seat of the disease, but again the patient will be sick for months before the trouble can be located. The patient usually gives a history of having had frequent periods of illness; he looks unhealthy; his skin is sallow and sometimes actually jaundiced; there is debility and emaciation; the pulse is irregular and there is fever of the hectic type, attended by occasional rigors or chills. There is a dull, aching pain over the liver and sometimes in the right shoulder; the tongue is coated and there is derangement of digestion. On physical examination the liver will be found large and tender, the enlargement being mainly upward and to the right, contrary to the usuall direction of hepatic swelling. Occasionally fluctuation may be detected.

Diagnosis. This is often difficult. The individual symptoms are of little value, and it is only by grouping them that a conclusion can be reached. The condition is to be differentiated from malaria, from an inflamed and distended gall bladder, and from hydatids and cancer of the liver. The diagnosis is based on irregular fever with chills and sweats, tenderness and swelling of the liver and the slight jaundice. If a blood count is made there will be found a sufficient degree of leucocytosis to indicate the existence of suppuration. In doubtful cases aspiration or exploratory incision should be performed. If pus is found it will be of a peculiar reddish brown or chocolate color. An examination of it will show bile pigments, liver cells, staphylococci or amebæ. An abscess of the liver may rupture into the pleura and be aspirated from this cavity under the mistaken idea that the patient has empyema; or again it may burst into the lungs and be coughed up. In both cases the characteristic color of the pus should prevent a mistake in diagnosis.

Prognosis. The mortality of liver abscess is from 50 to 60 per cent. Multiple abscesses occurring in the course of general pyemia are almost invariably fatal. Large single abscesses frequently are cured by early surgical intervention.

Treatment. When an abscess of the liver is definitely located, it should be treated as any other abscess—namely, by incision, evacuation and drainage. If neglected, absorption may lead to fatal septicemia or rupture into the pleural or peritoneal cavity to fatal complications. The patient should be prepared as for any other major operation, and after being anesthetized a free incision should be made where the swelling is most prominent. Often the parietal and visceral peritoneum will be found adherent one to the other, and the abscess may be entered without opening the general peritoneal cavity. If, however, on making the incision such is found not to be the case, the two layers of the peritoneum should be stitched together and the union protected by a packing of gauze before the hepatic structure is opened. If by palpating the liver the fluctuation of pus cannot be detected, an effort should be made to definitely locate the abscess by plunging an aspirating needle or grooved director in the direction it is supposed to exist. When the cavity is entered, which can be determined by the sudden absence of resistance, or by the escape of a small quantity of pus, a free opening should be established by pushing a pair of closed hemostatic forceps into the cavity and widely separating the blades. The finger should then be introduced and any trabeculæ broken down and all pockets of the abscess thrown into one main cavity. The abscess should then be irrigated, or mopped out with gauze sponges, and free drainage provided by the insertion of one or more large rubber tubes.

ABSCESS OF THE BREAST.

An abscess of the breast is a circumscribed collection of pus in the mammary gland.

Causes. Abscess of the breast may occur in a man, woman or child, the cause being the same as those of abscesses in other localities—namely, traumatism and infection. Practically, however, almost all abscesses occur in nursing women. The engorgement of the breast due to lactation, lowering its vitality, and abrasion or fissures of the nipple, admitting infection. The collection of pus may be (1) just beneath the skin, or a subcutaneous abscess; (2) between the lobules of the gland, or a glandular abscess, and (3) in the connective tissue behind or under the gland, a post-mammary or subglandular abscess.

Symptoms. There is usually a slight chill, followed by fever, loss of appetite and other constitutional symptoms. There is a throbbing pain in the breast attended by a feeling of distention. If the abscess is subcutaneous there is prompt development of redness, swelling, and fluctuation as seen in an ordinary furuncle. If the abscess is in the gland proper, the breast becomes hard, indurated, and the superficial evidences of suppuration do not appear for some days. If the abscess is post-mammary, the pain is deep-seated. An area of edema appears around the breast as a ring, and when suppuration occurs there is a characteristic elevation of the gland and it floats on the pus as if it were on a water bed.

Diagnosis. The diagnosis is based on the history, the combination of the local and general symptoms, and if necessary by making an exploratory puncture.

Treatment. The prophylactic treatment is the most important and consists in the proper care of the woman's breast for several months before delivery. If there be retracted nipple, the condition should be corrected by systematic massage. If they are fissured or cracked, they should be treated by the use of nitrate of silver, followed by antiseptic dressings. After the birth of the child it should be the nurse's duty to see that the breasts are emptied regularly and alternately and that the nipples are cleansed after each nursing with a boric acid solution or some other non-toxic antiseptic. Attention should also be paid to the cleanliness of the child's mouth. When inflammation of the breast develops, the child should be stopped from nursing and the breast should be kept emptied of milk by the breast pump, systematic massage, and the use of pressure. A cold application to the breast, either by an ice coil or an ice bag, will relieve pain and sometimes abort the formation of pus.

When suppuration occurs a prompt operation is indicated. The incision should be made so as to give drainage by gravity, and should be in the direction of the lacteal ducts so as to avoid their injury, that is from the nipple to the periphery as the spokes in a wheel. The abscess cavity being entered, the finger should be introduced and all compartments broken up. The wound should then be irrigated and drained with a tube or strip of gauze, a suitable dressing applied and a bandage applied so as to fix the arm to the chest wall. In dealing with the post-mammary abscess, a free curved incision should be made at the lower or outer part of the circumference of the breast, the gland lifted from the chest wall, drainage inserted, and then the breast sutured back in position.

ABSCESS OF THE LUNG.

An abscess of the lung is a circumscribed collection of pus in lung tissue. Properly speaking, the term does not include the so-called tubercular abscess of the lung.

Causes. The essential cause is the pyogenic germ, usually the streptococcus or staphylococcus. The predisposing cause is any factor which weakens resistance. Abscess of the lung often follows unresolved pneumonia or gangrene of the lung. Inhalation of a foreign body frequently conveys infection and creates a point of lowered vitality. General pyemia, puerperal septicemia, ulcerative endocarditis, and suppurative osteomyelitis may be the sources of the embolic infection of the lungs. Suppuration may result in the diffusion of many small abscesses through a wide area of lung tissue, or more commonly one or two cavities may result.

Symptoms. Pallor of the face, night sweats, emaciation, cough and expectoration, fever and local pain are symptoms attending this condition, but also found with other diseases, such as tuberculosis.

Diagnosis. If from the clinical history and a careful physical examination of the chest, it would seem probable that there was some sort of cavity in the lung, the question arises, is it tubercular or suppurative. If it is tubercular an operation will do no good, whereas, if it is suppurative an operation is imperatively demanded. Such a case should never be subjected to surgery without resorting to aspiration and having the fluid removed examined by the microscope. By means of percussion and auscultation the area affected is carefully mapped out. Under careful aseptic precautions an exploring needle is passed through an intercostal space and pushed onward until the cavity is entered and the fluid is obtained for examination.

Prognosis. As a rule death results either primarily from septicemia or secondarily from tuberculosis. A large single abscess gives more promise of recovery than a number of smaller ones.

Treatment. Prior to the introduction of aseptic surgery cases of lung abscess were invariably fatal. Under modern methods, however, many cases have been saved.

When the abscess is definitely located it should be approached by an opening of satisfactory size through the thorax, and this can only be secured by the resection of one or more ribs. When the pleura is reached, it will generally be found that the parietal and visceral layers are adherent. If this is not the case, the two layers should be carefully stitched together or tamponed with gauze to prevent the pus from the abscess entering the pleural cavity and causing a complicating empyema. The abscess should again be located by the insertion of an exploring needle. The intervening lung tissue should then be opened by means of a Paquelin thermocautery. The advantage of this instrument is that it effectually seals the blood vessels, preventing hemorrhage; that it produces an eschar which protects the adjacent tissue from infection, and finally that it makes a tract well adapted to subsequent drainage. After the cavity has been opened and the pus evacuated, arises the question of whether or not it should be irrigated. If it communicates with a bronchus the fluid might pass into the lungs and drown the patient. It is, therefore, safest merely to sponge out the cavity and insert a rubber tube and pack with a strip of iodoform gauze. The after treatment should be carried out on general principles.

ABSCESS OF THE BRAIN.

An abscess of the brain is a circumscribed collection of pus in brain tissue. Pus between the brain cortex and its membranes is not a brain abscess, but a form of suppurative meningitis.

Cause. The essential cause is, of course, the pyogenic germ. Fifty per cent of cases are secondary to suppurative disease of the middle ear. Next in frequency are simple or compound fractures of the cranial vault. A contusion of the brain not severe in itself, and from which apparent recovery has long ago taken place, may be followed by the development of an abscess. If the abscess follows traumatism it is generally situated beneath the site of the injury, and in operating on such a case it will be well to search for the scar, as it will serve a useful purpose in localization. Occasionally the abscess will be located on the opposite side of the head, laceration of the brain having occurred by *contrecoup*. Brain abscesses vary in size from a cavity holding only a teaspoonful of pus to one occupying a large portion of a hemisphere. They are usually single.

Symptoms. The symptoms of abscess of the brain will vary with the acuteness of the disease. Chronic abscesses often cause no symptoms. Again, they produce irritability of temper, depression of spirits, extravagance, carelessness and a disregard of business duties and social customs. A chronic abscess usually, after months or years, suddenly becomes acute. The symptoms of acute abscess of the brain can best be discussed under three heads:

1. *Toxic Smyptoms.* As a rule there is a chill, followed by nausea, anorexia, and general malaise. The temperature is generally but by no means always elevated, and may be normal or subnormal, thus differing from suppuration in other parts of the body.

2. *Pressure Symptoms.* Of these headache is probably the most constant, being always present and at times extreme. It may be localized or general. A slow pulse is usually present and significant. Cheyne-Stokes respiration is often noted. There is usually excitement, then stupor, and finally coma. The pupil is generally dilated on the affected side and more or less responsive to light. The bowels and bladder may be evacuated involuntarily. It is a curious fact that all of these symptoms fluctuate widely—at one time improving, so as to give hope of spontaneous recovery, only to reappear shortly in a more grave degree.

3. *Focal or Localizing Symptoms* are the evidences of the perversion of the function of some portion of the brain. For instance, if the abscess involve Broca's convolution, there will be interference with the motor part of speech; or if it involve the area of Rolando, there will be interference with the motor functions of some of the skeletal muscles.

Diagnosis. The diagnosis is based on the history of suppurative diseases of the ear, fracture or other injury to the vault, etc.; also on whether the patient has had headache, alteration in his normal temperament, or other symptoms indicative of the existence of cerebral irritation. Finally, the presence or absence of the toxic, pressure and localizing symptoms previously described. The determination of the exact location of the abscess requires a thorough knowledge of cerebral topography and can usually be done only by a specialist. The location of pain, or local tenderness, or the presence of a scar are important, but the focal symptoms are the most important factors to be considered. The normal functions of certain areas of the brain are well known, and interference with these functions would indicate the presence of pressure on the area which presides over them.

Treatment. The treatment of cerebral abscess is fundamentally the same as the treatment of collections of pus elsewhere. The indications of incision, evacuation, and drainage are most imperative, for pus confined within the unyielding skull has no means of exit, and its expansion must be at the expense of the delicate structures which it contains. The patient's head should be shaved and the skull opened over the point at which the abscess is supposed to exist. If there be a scar and the focal symptoms point to the region underlying it, the work of localization is much simplified. If, however, the scar does not agree with the focal symptoms, the skull should be opened in accordance with the science of cerebral localization rather than upon the indications of the history of the injury. The opening may be made either with a trephine, chisel, or bone-cutting forceps. When the dura is reached it should be incised. When the brain structure is exposed it will probably bulge through the opening if the abscess be present, and, furthermore, the normal pulsations of the brain will be absent. A grooved director should be pushed with care and gentleness in the direction of the supposed abscess. It may be carried two or two and a half inches into the brain. If the abscess is not found it should be withdrawn and reintroduced in another direction. If the pus collection is reached it will be demonstrated by the sudden loss of resistance and by the escape of the pus along the groove of the instrument. When the abscess is located the director should be left in position to act as a guide and a pair of forceps forced by its side to make an opening large enough for drainage. After the abscess is empty, its walls should be gently irrigated to remove the necrotic tissue and drained with a tube or strip of gauze. Copious antiseptic dressing should be applied and changed according to the indications in the case.

LECTURE XVII.

SUPPURATIVE ARTHRITIS—SUPPURATIVE MENINGITIS—SUPPURATIVE PLEURITIS AND SUPPURATIVE PERITONITIS.

This lecture takes up a discussion of suppuration as it occurs in certain of the large cavities of the body. As an introduction, it is well to call attention to certain features that are present in all of them. The cavities, or preformed spaces, involved are normally lined by synovial or serous membranes. An inflammatory process once inaugurated spreads rapidly until the entire surface of the cavity is affected. The products of the inflammation, serum or pus, soon fill the space, there being no avenue of escape. The infection of the cavity occurs in one of three ways: (1) By direct infection through opening traumatism; (2) by the extension of suppuration from neighboring structures, and (3) by the localization of a germ borne by the blood. The symptoms which result include toxemia from the absorption of pus and the mechanical results which follow distention of the pre-formed space. The surgical treatment for all consists in the evacuation of the pus and the sterilization of the cavity from which it was removed.

SUPPURATIVE ARTHRITIS.

Suppurative arthritis is a suppurative inflammation attacking a joint, and is due to the localization of pus germs in the synovial membrane (suppurative synovitis), from which primary focus the extension extends to other structures, and unless relieved is followed by complete disorganization of the joint (panarthritis).

Cause. The cause is infection of the joint with the bacteria of suppuration, the organisms most common being the streptococcus, the staphylococcus, the pneumococcus, the gonococcus, and the bacillus typhosus. Infection may occur in one of three ways: (1) By direct infection through an open wound, (2) by the extension of suppuration from neighboring osteomyelitis or periarthritis; (3) by transmission to the synovial membrane of a pyogenic germ present in the blood of the patient.

Symptoms. The local symptoms are such as might be expected. Pain is severe, being worse at night; tenderness is marked, swelling is great; the skin is hot and red, and fluctuation soon becomes distinct. The joint is reflexly flexed, as this position increases its capacity and minimizes tension. There is muscular rigidity. The constitutional symptoms are often grave; there is chill with rapidly rising fever, the temperature going to 103 or 104° Fahrenheit, and continuing with but slight intermissions. The pulse is at first full, strong, and bounding, but soon becomes weak and rapid, and unless relief is afforded by spontaneous or surgical evacuation of the pus the "typhoid state" sets in and there may be death from septicemia.

Diagnosis. The diagnosis is easy in a typical case and is based on the history and local symptoms. The disease may be mistaken for acute articular rheumatism, but is differentiated by the fact that in rheumatism more than one joint is involved, the fever is irregular and followed by acid sweats, and there are characteristic urinary signs.

Prognosis. The prognosis to life is good if the condition is recognized early and treated properly. A stiff joint often results, however, in the hands of the best surgeons.

Treatment. Arthritis occurring as a result of gonorrheal infection may sometimes yield to aspiration, compression and immobilization, combined with vigorous treatment of the primary seat of gonorrhea usually the urethra. All forms of suppurative arthritis demand incision, evacuation, irrigation and drainage. The location of the incisions will, of course, vary with the joint. They should be placed so as to give the best drainage. In the case of suppuration of the knee it is generally necessary to make four openings, two above and two below the patella. Through these incisions by means of a hemostatic forcep a fenestrated rubber drain is carried transversely across the upper and lower portion of the synovial sac. Irrigation of the joint should be practiced with a solution of peroxide of hydrogen, carbolic acid, or bichloride of mercury. During the subsequent treatment the joint should be kept immobilized by means of a suitable splint, and passive hyperemia employed. Since ankylosis frequently results, it is well to place the limb in the position which will render it most useful should the function of the joint be destroyed, that is in flexion if it be the elbow and extension if it be the knee. If suppuration continues, despite all that can be done, and the patient's life is threatened from exhaustion or sepsis, excision or amputation may be needed. The constitutional treatment is that of suppurative diseases in general, such as good food, stimulants, tonics, etc.

SUPPURATIVE MENINGITIS.

Suppurative meningitis is a general term used to indicate suppurative inflammation of one or all of the membranes of the brain and spinal cord. The meninges are three in number—namely, from without inward, the dura mater, the arachnoid, and the pia mater. Inflammation of the outer covering, the dura mater, is called pachymeningitis. Inflammation of the arachnoid, pia mater, and superficial surface of the cortex of the brain is called leptomeningitis. Suppurative pachymeningitis may occur as a local or as a diffuse condition. Suppurative leptomeningitis rarely localizes and often proves fatal before well-marked evidence of suppuration occurs.

Cause. Suppurative meningitis is due to a pus germ. Infection may take place directly by a penetrating wound of the skull, as in a compound fracture, or by extension of suppuration from a neighboring focus, as from middle ear diseases, or by localization of a pyogenic organism floating in the blood.

Symptoms. Pachymeningitis is often local; leptomeningitis is practically always diffuse. If is important to try to differentiate the two by the symptoms which result, as in one, operative intervention may result in a cure, while in the other no good can result.

Localized Suppurative Pachymeningitis frequently follows an injury and manifests its first symptoms the second or third day.

There is usually severe headache, followed by considerable fever; the pulse is quick, full and bounding; the face is flushed, the pupils contracted, and there may be a rise of local temperature. As the accumulation of pus increases the symptoms of irritation give way to those of compression and the pulse becomes slower. Often there are focal symptoms, which in the early stage may consist in spasm of definite groups of muscles; and later, when the irritation is replaced by compression, consist in complete paralysis.

Diffuse Suppurative Leptomeningitis. The symptoms here are due to the involvement of the cortical surface of the brain. At first there is languor, malaise, headache, irritability, vertigo, anorexia and vomiting. This is followed by a chill, high fever, and symptoms of septic intoxication. There is rigidity of the neck, hyperesthesia of the skin, contracted and often unequal pupils, insomnia, restlessness and delirium. The vomiting becomes explosive and projectile in character. The patient falls into short naps and is awakened by convulsive seizures. In time these symptoms of irritation give place to those of compression, and in place of spasm there is paralysis. Excitement and mania deepen into stupor and coma. Spasm and convulsions give place to monoplegia and hemiplegia. The congested face becomes pallid and the hot skin is bathed with a cold, clammy perspiration; the pupils dilate and do not respond to stimulation; the pulse stops bounding and becomes small and rapid. Death is frequently preceded by relaxation of the sphincters.

Treatment. The prophylactic treatment consists in the proper management of accidental injuries to the skull. A patient with a compound fracture of the cranium should be regarded as in imminent danger of infection and guarded against it by the most pedantic precautions. The entire scalp should be shaved and thoroughly disinfected. If the fracture involve the tympanum the external ear sould be cleansed and packed with cotton. If the naso-pharynx be involved the space should be douched and packed. The wound on the vault should be enlarged, all clots of blood, spiculæ of bone, and foreign bodies removed, depressed fragments elevated and after bleeding has been controlled the wound closed with a drain and protected with antiseptic dressings.

When suppurative meningitis develops, the surgeon must try to determine whether he is dealing with a localized collection of pus or a widespread infection, as, in the first, he may operate with a chance of success, while in the second, his efforts are foredoomed to failure. If the collection be local, the pus should be approached either by increasing the size of a pre-existing opening in the skull or by cutting a new opening with a trephine or bone forceps. When reached, the cavity should be emptied, disinfected and drained. The subsequent treatment consists in combating the septic intoxication and in the proper management of the wound. When suppuration is diffuse the case is practically hopeless and the surgeon may well question the propriety of bringing his profession into disrepute by attempting the impossible. It has been proposed in such cases to make multiple openings in the skull, open the dura and practice continual irrigation of the underlying membranes, but up to this time, as far as literature shows, no case has been saved by the method.

SUPPURATIVE PLEURISY.

Suppurative pleurisy is a suppurative inflammation attacking the pleura, resulting in a collection of pus in the pleural cavity, commonly termed empyema.

Cause. The most common pyogenic organisms responsible for the condition are the staphylococcus, the streptococcus and the pneumococcus. They may gain entrance in the three ways already discussed—by direct infection, as from a stab wound; by extension of suppuration, or by being carried by the blood.

Symptoms. There are the usual symptoms which inaugurate suppurative processes elsewhere—namely, chill, fever, loss of appetite, prostration, etc. Often there is dyspnea associated with a short, hacking, aborted cough. Upon physical examination there is sometimes seen a slight edema of the skin on the infected side and some bulging of the intercostal spaces. Percussion will give dullness where normally there should be resonance, this being due not only to the presence of pus, but also to the displacement and compression of the lung. Auscultation will show absence of normal sounds. The diagnosis can be made positively by the use of an aspirating needle introduced through an intercostal space.

Prognosis. The prognosis depends somewhat on the character of the infection, the pneumococcus being more favorable than the staphylococcus, and the staphylococcus more favorable than the streptococcus. Much depends upon early diagnosis and prompt surgical treatment. Delay results not only in general debility from sepsis, but in the formation of adhesions about the lung, which prevent its expansion and thereby cause the formation of a dead space after the removal of the pus from the pleura.

Treatment. A collection of pus in the pleura should be treated like a collection of pus elsewhere, and as soon as its existence is detected an operation is indicated. Aspiration is often advisable for diagnosis and is sometimes useful to give temporary relief, but it must not be depended on to secure a cure. An operation for empyema should consist in the removal of a section of one or more ribs, for unless this is done satisfactory drainage cannot be secured. An incision should be made three or four inches long immediately over, and parallel with, the sixth or seventh rib in the mid-axillary line. The periosteum of the rib should be reflected and a section of the bone removed with cutting forceps. The parietal pleura should then be opened, when if pus be present there will be its immediate escape. The cavity should not be emptied too rapidly for fear of syncope, but the flow of pus should be interrupted occasionally by the insertion of a finger into the opening. The question of irrigation must be decided in each individual case. If employed the solution should be used at blood heat, as cold solutions cause great shock. Drainage can best be effected by the insertion of two large rubber tubes, which should be fastened by a stitch to the margin of the wound to prevent them slipping into the pleural cavity, a complication which has happened in many cases. A voluminous antiseptic dressing should be applied and this should be changed daily.

In certain neglected cases of empyema it will be found that owing to the long compression of the lung, it has become collapsed and bound down by adhesions so that it cannot expand and fill the cavity it formerly occupied. If the lung, owing to its being "stuck on itself," cannot expand to meet the thoracic wall, and the thoracic wall, owing to the rigidity of the ribs, cannot collapse to meet the lung, then a dead space is left, which, if uncorrected, will inevitably result in the death of the patient, either through long continued suppuration or secondary tubercular involvement. To deal with this condition, two classes of operations are employed one consisting in opening into the pleural cavity and forcibly tearing and breaking up the adhesions until the lung is able to expand; the other in resecting the ribs and crushing in the thoracic wall by methods such as those devised by Schede or Estlander.

SUPPURATIVE PERITONITIS.

Suppurative peritonitis is suppurative inflammation attacking the peritoneum. No two text-books adopt the same classification of the different degrees of this condition. While not strictly scientific, the one given by Senn is probably the best from a practical standpoint. He uses the term (1) septic peritonitis, in which the infection is so acute and virulent that death follows before sufficient time has elapsed for pus to form; (2) diffuse suppurative peritonitis, in which the patient lives long enough for the infectious agent to produce pus, but the process is so rapid that the system is unable to retard its dissemination or prevent its diffusion over practically the entire peritoneal surface; and (3) local suppurative peritonitis, where, owing to the character of infection, there is the formation of pus, but its development is so slow that the system has time to form adhesions of omentum, intestines, and other viscera and thus form a wall by which the infectious fluid is confined to a limited portion of the peritoneal cavity.

Cause. The essential causes are the pyogenic organisms. The germs most often responsible for septic or suppurative peritonitis are the streptococcus, the staphylococcus, the gonococcus, the bacillus typhosus, and the bacillus coli communis. These germs may reach the peritoneal cavity (1) by direct infection through an accidental or operative wound; (2) by extension of suppuration from a gastric or duodenal ulcer, empyema of the gall bladder, appendicular abscess, or ruptured pyo-salpinx; (3) by infection through the blood, as is sometimes seen when suppurative peritonitis develops during the course of a general pyemia. As predisposing causes, or the factors favoring the development of the condition in the presence of the infectious agent are included conditions which lower the resistance of the peritoneum. It is a well-known fact that the healthy peritoneum can successfully deal with a limited amount of infection. Its capacity in this direction, however, is much lowered by long exposure to the air, by rough handling, by the presence of blood clots, and by antecedent diseases.

The Symptoms of Septic Peritonitis are those of acute sepsis. They appear so quickly that they are often mistaken for shock. The temperature is often subnormal, the pulse is rapid and thread-like, the skin is cold and clammy, the face is pallid and ashy, the abdomen is flat and soft—there not having been time for distention or rigidity to develop. The patient is apathetic or indifferent; the mind however is clear. Death usually results in from twelve to twenty-four hours.. On opening the abdomen at the post-mortem the peritoneum is found red and angry, with perhaps the presence of a small quantity of bloody serum. There is no pus, because it has not had time to form.

The Symptoms of Diffuse Suppurative Peritonitis are plainly marked, as here they have time to fully develop. They first appear about twelve to twenty-four hours after the accident or operation. There is pain and tenderness of the abdomen, beginning about the umbilicus, but later becoming general. The temperature slowly rises, being first 100, in a few hours 102 and 106 or 108° Fahrenheit. The pulse is rapid and wiry and progressively loses strength with the advance of the disease. The quality of the pulse is a better index to the condition of the patient than the temperature. Respiration becomes quicker and is thoracic in character; the abdomen becomes distended and its walls stiff and rigid. It is impossible to move the bowels by purgation, owing to paresis of the intestines from toxemia and distention. Vomiting is almost constant, the material consisting first of the stomach contents, then of mucus and bile, and finally as death approaches the patient turns the head to one side and without nausea or effort regurgitates mouthfuls of black fluid which has an extremely offensive odor. Upon examination it will be found to consist largely of blood and it is believed that it has its origin from the congested gastric mucosa. The patient early assumes the dorsal position and lies with the trunk motionless and the knees and hips flexed. The face becomes gray and wears an expression of anxiety; the nose is sharp, cold and pinched; the eyes sunken, the cheeks collapsed and the lips blue. The intellect generally remains clear and "while there is often a total lack of realization of the inevitable and usually dreaded end, it is as often thoroughly appreciated by the patient and viewed with a calmness which increases the awe, which always attaches to the presence of the shadow of death."—Tyson.

If the abdomen is opened either during life by the surgeon, or after death by the pathologist, it is found to contain a large quantity of free turbid fluid resembling pea soup. The intestines are widely distended, red and congested, and covered by numerous flakes of lymph.

The Symptoms of Localized Suppurative Peritonitis begin very much like those of general suppurative peritonitis, except that they are not so acute, and usually rapidly improve when the effort of nature is successful in confining the suppurative product to one part of the abdomen. The patient suffers pain first about the umbilicus, then over the entire abdomen, and finally localized at the seat of the abscess. Tenderness is also at first general, but later becomes local. The temperature is at first markedly elevated, but later may become normal. The abdomen is at first distended, but later tympanites disappear and rigidity is limited to the region involved. Frequently a patient will come into the hospital with a normal pulse and temperature, little or no pain, and an abdomen that is flat and soft, except over the pus collection, where it is hard and tender. Sometimes the tension of the pus is so great as to make an abscess simulate a solid tumor. Again, careful palpation may elicit fluctuation. When the abdomen is opened, a quart or more of offensive pus may be found separated from the adjacent viscera by a barrier of lymph, the other portions of the abdomen being, to all appearances, normal.

Diagnosis. The diagnosis of septic or suppurative peritonitis is based on the history and the symptoms just described. When in doubt, a blood examination will often settle the question of whether or not pus is present.

Treatment. This subject is too extensive to completely consider. The preventive treatment consists in the use of proper aseptic and antiseptic measures in all abdominal work and in the careful investigation of any symptom in a patient which may point to a trouble likely to lead to a peritoneal infection. Thus an early diagnosis and cure of an ulcer of the duodenum, empyema of the gall bladder, imflammation of the appendix, or suppuration of the Fallopian tubes may avert the danger under which the patient labors. When *septic peritonitis* develops, the patient is usually doomed and efforts are of no avail. The infection is so acute and the progress of the disease so rapid that nothing can be done except to palliate symptoms.

In *Diffuse Suppurative Peritonitis*, a prompt operation gives the only chance for life. Formerly, patients were opened, eviscerated, washed out with gallons of saline solution, and drained through mutiple incisions. The present practice is to make an incision over the suspected focus of infection, say, a perforated intestine, or gangrenous appendix, stop the introduction of additional infection by closing the perforation or removing the appendix, put in a large rubber drain, which should reach to the most dependent point, which is Douglas' cul-de-sac in the female, and the corresponding peritoneal pouch in the male; and then, without attempting irrigation or cleansing of the cavity, place the patient in a sitting position in bed. This relieves peritoneal tension, which is forcing sepsis into the circulation, drains toxic fluids from the absorptive surface of the peritoneum of the upper abdomen to the practically unabsorptive surface of the pelvis, from which point it escapes through the tube to the dressings.

This surgical and postural treatment should be aided by the introduction into the system of large quantities of fluid which can best be done by Murphy's low pressure continuous introduction of normal salt solution. By overfilling the vessels the peritoneum is made a secreting instead of an absorbing surface. If there is nausea the stomach should be irrigated. Morphia should be given to relieve pain and sulphate of spartine to stimulate the heart and kidneys. No nourishment or purgatives should be given by mouth until the crisis is passed.

The treatment of *Localized Suppurative Peritonitis* consists in incision, evacuation and drainage of the abscess without opening the general peritoneal cavity, if this be possible. For instance, if a pelvic abscess can be palpated through the vagina, it should be opened by puncturing the vault of this canal and drained by the insertion of a tube or gauze. If an appendicular abscess can be mapped out and it is adherent to the abdominal wall, it should be opened and drained, and care taken not to break down the barrier which nature has formed as a protection for neighboring viscera. If, as is sometimes the case, it is found impossible to reach the abscess without opening the cavity, then, after incising the abdominal wall, the healthy structures should be carefully protected by walling them off with hot moist pads of gauze before the abscess is opened. The contents of such an abscess should be carefully sponged out, the focus from which it originated searched for and removed, and drainage so placed as to convey away the pus which will subsequently form without allowing it to infect the healthy peritoneum.

LECTURE XVIII.

SUPPURATIVE OSTEOMYELITIS—CAUSE, PATHOLOGY, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT.

Suppurative osteomyelitis is an acute suppurative inflammation beginning in the medullary cavity of bone. It is a disease of frequent occurrence, often disastrous in results, and in its early stages difficult to diagnosticate. If recognized early the deformity to limb, or danger to life, can be averted. If allowed to go untreated, the result may be a reproach to the attendant, and disastrous to the patient.

CAUSES.

Suppurative osteomyelitis is caused by the ordinary pyogenic germs. At one time it was supposed to be due to a special organism, but this claim has been refuted. It is now known that suppurative osteomyelitis and furuncle have essentially the same etiology; in fact, suppurative osteomyelitis is sometimes spoken of as furunculosis of bone. An investigation of thirty-five cases of the acute disease showed that in twenty-one cases the infection was with the staphylococcus pyogenes aureus, in seven cases the staphylococcus pyogenes albus, in three cases the streptococcus, in two cases the pneumococcus, and in the remaining two the nature of the microbe could not be determined. In still other cases reported the bacillus typhosus, the bacillus pyocyaneus, the micrococcus pyogenes tenuis, and the bacillus coli communis have been found.

In the form of suppurative osteomyelitis now being described there is no open wound and the germs gain access to the medullary cavity of bone by being conveyed to it by the blood. The predisposing causes to suppurative osteomyelitis are age, sex, cold, traumatism and acute infectious diseases. (1) *Age.* Suppurative osteomyelitis almost invariably begins between the third and fifteenth year. This is the period of development, when growing bone presents such peculiarities as to make it readily susceptible to infection. (2) *Sex.* The disease is more common in boys than in girls, because the former lead a more active and outdoor life and are more exposed to traumatism and cold than girls. (3) Exposure to *cold* is another predisposing factor, as it causes congestion and favors localization of floating micro-organisms. (4) *Trauma* is another indirect cause, as it creates a lowered vitality. Frequently in cases where the disease results there will be a history of a contusion, blow or fracture from which recovery apparently took place to be followed later by the development of the disease. (5) *Acute infectious diseases,* such as smallpox, typhoid fever, scarlet fever, measles, and diphtheria, seem to prepare the medullary tissue for infection. Keen reports sixty-nine cases of suppurative osteomyelitis following infectious diseases; typhoid fever was responsible for thirty-seven. He explains it upon the theory of septic thrombosis for the early cases and enfeebled nutrition for the late ones.

PATHOLOGY.

The disease most frequently attacks the long bones, such as the femur and tibia. It is also sometimes seen in the scapula, clavicle and ribs. It almost invariably begins at the juncture of the diaphysis with the epiphysis, or shaft with the extremity. This is due to the peculiar histologic structure of the part before ossification is complete. During growth the cells are embryonic, possess little resistance and the circulation of the blood is sluggish, owing to the capillaries being large and imperfectly developed. In fact, the epiphyseal line of bone is so susceptible to all diseases that it has been termed the "zone of pathologic election." The pus microbe, gaining entrance to the circulation through the respiratory or alimentary mucous membrane, or from a pre-existing focus, is carried by the blood to the medullary cavity of bone and, finding in that tissue a favorable soil, owing to the anatomic or pathologic condition present, effects localization and produces inflammation. The reaction is usually acute and intense and the alteration in the capillary walls such as to allow the escape of blood elements by rhexis. There is exudation and transudation and the conversion of these products into pus. Owing to the inflammation occurring in the cavity of bone and being circumscribed by rigid inelastic walls, which do not permit of expansion, the tension is great and necrosis from pressure results. From this abscess in the hollow cavity of the bone the inflammation extends in the form of a suppurative phlebitis towards the surface until finally it reaches the periosteum. This structure is tough and for a time sufficiently resistant to withstand the effort of pus to make its way through it; consequently the pus burrows beneath it and strips it from the bone. Finally the periosteum ruptures and the confined infectious fluid escapes. Active manifestations of suppuration develop in the overlying soft structures until finally pus reaches the surface and discharges by an opening through the skin. With the relief afforded by this natural drainage there is usually rapid improvement and reparative processes are inaugurated.

The portion of bone which has been killed by pressure and poison separates from the adjacent living bone and lies loose as a foreign body, and is called the *sequestrum*. New bone is thrown out to form a case around the dead bone and this is called the *involucrum*. To give drainage an opening or sinus is formed from this cavity to the surface of the bone and this is called the *cloaca*. The three terms may be impressed by considering the sequestrum the corpse, the involucrum the casket, and the cloaca the opening through which may be viewed the face.

SYMPTOMS.

General Symptoms. Premonitory symptoms of suppurative osteomyelitis include indisposition and general weakness. These are soon followed by a chill and rapid rise of temperature with other characteristic evidences of toxemia and sepsis. In certain cases, fortunately rare, where infection attacks several bones simultaneously, the patient rapidly passes into the "typhoid state," characterized by muttering delirium, dry tongue, diarrhea, quick pulse, burning fever, swiftly progressing prostration, and death.

Local Symptoms. Fortunately in the average case, the local symptoms are well marked, and if carefully weighed will give timely evidence of the nature of the disease.

1. *Pain* is one of the earliest and most constant. It is boring, tearing, or throbbing in character and marked by exacerbations at night. It is due to the tension of pus confined in the unyielding bone. It grows worse as the quantity of pus increases and is immediately relieved when the pus perforates the periosteum and escapes into the soft structures. It is not, as a rule, strictly localized, but is frequently referred by the patient to the neighboring joint.

2. *Tenderness* is the most reliable of the early symptoms because, while pain is diffuse, the area of tenderness, as elicited by the surgeon's fingers, will correspond to the extent of the disease, and, furthermore, it will be found that it is most marked at the point where pus is nearest the surface. Tenderness, therefore, is valuable in determining the site for an early operation.

3. *Swelling* is absent in the early stages of osteomyelitis, because it cannot occur until the pus burrows through the bone and attacks the soft structures. It usually begins when acute pain stops. It is not a symptom of suppurative osteomyelitis, but a result or complication. Its absence in the early stage should not deter an immediate operation, but rather favor one.

4. *Synovitis,* or the involvement of a neighboring joint, may be simply an effusion due to vascular disturbances, or may be suppurative due to direct extension of inflammation. If it is merely mechanical it does not require the same active treatment as it does when it is infectious.

5. *Epiphyseolysis,* or the pathological fracture of bone at the juncture of the epiphysis with the diaphysis, is due to the destruction of bone at this point, and is recognized by the displacement or unnatural mobility, such as occurs in an ordinary fracture.

6. *Loss of Function* is noted. A patient with suppurative osteomyelitis will not attempt to use the affected limb and will resist passive motion on the part of the surgeon.

DIAGNOSIS.

Suppurative osteomyelitis is not usually recognized by the attendant in its early stage. It is mistaken for periostitis, ostitis, arthritis, rheumatism, erysipelas and typhoid fever. Holmes states that in the old days the diagnosis was more frequently made at the postmortem than at the patient's bedside. The nature of the disease cannot be decided by a consideration of any one symptom, but only by grouping them all together. The age and sex of the patient, the history of an injury, however trivial, the existence of a suppurative process, however insignificant, and the recent history of typhoid fever or other infectious disease must be carefully considered. Next the general symptoms, the chill, fever, prostration, and finally the local manifestations of the disease, the presence of boring, tearing pain referred to a limb or joint, the existence of tenderness near, but not in, a joint—that is at the epiphyseal line—and the absence of swelling, heat, and redness ought to lead to a proper appreciation of the condition. If the case is seen later, after swelling develops, pus forms and discharges, the history of the case, plus the results that have followed, leave no doubt as to the nature of the disease. Suppurative osteomyelitis can be differentiated from primary arthritis by the difference in the seat of the point of greatest tenderness, from acute articular rheumatism by the fact that in rheumatism the pain shifts from one joint to another and suppuration does not occur; from typhoid fever by the fact that in typhoid fever the onset is gradual, while osteomyelitis is ushered in full fledged with a chill, high fever, and exquisite pain at or near a joint. Should multiple osteomyelitis occur and there be an overwhelming initial dose of poison the patient may pass at once into a stupor, and die before a diagnosis can be made.

PROGNOSIS.

Under this must be considered (1) the danger to life and (2) the danger to permanent disability of limb. Before the days of aseptic surgery from 25 to 50 per cent of the cases of suppurative osteomyelitis died from septicemia, pyemia, anemia, and degenerative changes, the result of prolonged suppuration. This mortality under modern methods has been markedly lessened. Some cases of multiple osteomyelitis are doomed to die; others can be saved by timely intervention.

The prognosis as to permanent disability of the limb depends on the extent of the disease and the promptness of the relief afforded by the surgeon. The patient rarely recovers without some deformity due to necrosis, arthritis, or epiphyseolysis, but a serviceable limb can usually be secured.

TREATMENT.

The general treatment of suppurative osteomyelitis consists in the administration of purgatives to empty the bowels, of opium or its alkaloids to relieve pain and of stimulants for the heart and respiration, the use of cold sponging to reduce fever, the immobilization and elevation of the affected part, and the selection of an easily digested and nutritious food. These measures, however, are entirely secondary in importance to surgical intervention for the mechanical correction of the trouble. Operations for osteomyelitis are divided into three classes with reference to the stage of the disease at which they are performed: (1) An "early operation," or one done before there is an extension of the disease from the medullary cavity to the periosteum—that is, before any external swelling is apparent; (2) an "intermediate operation," or one done after the inflammation has extended through bone and there is infection of the overlying soft structures but before there has been time for the sequestrum to form and (3) the "late operation," or one done for the removal of the sequestrum months or years after the disease developed.

An early operation for osteomyelitis is one of the triumphs of modern surgery. By it pain is almost instantly abolished by the relief of pressure; extensive necrosis is prevented, the danger of septicemia and pyemia minimized and complications, such as infection of soft structures, involvement of adjacent joints, and pathological fracture of bone are prevented. The disease is cut short and the patient's recovery hastened. The operation is preceded by disinfection of the part and the application of an Esmarch constrictor to render it bloodless. An incision is made over the area of greatest tenderness, which usually corresponds with the epiphyseal line. The skin and fascia are divided and muscular structures separated until the periosteum is reached. This is incised in the long axis of the bone and reflected with an elevator. A chisel and mallet are next employed and an opening made through the compact bone to the medullary cavity. As soon as pus is reached it is sponged out and the cavity disinfected, and drained. The constrictor is removed and any bleeding vessels ligated. Oozing from the bone cavity is best controlled by gauze packing, the ends of which are brought through the wound. A copious antiseptic dressing is applied and the part immobilized. The after treatment consists in the daily removal and replacement of the gauze packing until the cavity becomes healthy and heals by granulation. At the same time Bier's hyperemia may be employed. *An intermediate operation* is one done after infection has extended to the soft structures but before the sequestrum has formed. Necrosis has taken place, but sufficient time has not elapsed for the dead bone to become separated from the living. If the surgeon attempts to do a radical operation at this time he may make the mistake either of removing more bone than is necessary, or leaving bone which he ought to take out. He had better, therefore, content himself with making a sufficient number of openings in the skin to drain the soft structures and postpone his attack upon the diseased bone until Nature has had an opportunity to form the sequestrum. In rare cases at this stage the infection may be so virulent that in order to save the patient's life an amputation will be necessary.

A late operation is one done after the disease has run its acute course and Nature has separated the dead from the living bone. For this reason it is frequently spoken of as the operation of sequestrotomy. It is sometimes difficult to determine the exact time at which it ought to be done. If the patient's general health is improving there is no need of haste and nothing is lost and a great deal is gained by waiting. Again, however, the operation is unattended by danger and usually results in a cure, and if it is to be done sooner or later it had better be done soon. The steps consist in rendering the limb aseptic and bloodless, in dissecting through the soft structures to the bone, in opening the cavity of the involucrum with a chisel, and in removing the sequestrum. When this is done the surgeon is confronted by the problem how to fill the cavity left in the bone. The old plan was to disinfect and pack with gauze and allow to fill by granulation. This is safe and satisfactory, but entails a long convalescence. Various ingenious methods have been suggested to save time. One is to endeavor to crush or cause collapse of the walls of the involucrum, but this is only feasible when the case is comparatively recent and the bone to a certain degree malleable. Another is to suture the periosteum and overlying structures closely and then remove the tourniquet, allowing the cavity to become filled with blood, which on clotting will form a scaffolding upon which new bone will develop. Another is to pack the cavity with decalcified bone chips or with an iodized preparation of gelatin or with a preparation of iodoform, spermaceti and oil of sesami, known as the Mosetig-Moorhoff method. For further details the student is referred to books on practice of surgery.

LECTURE XIX.

ULCERATION AND ULCERS—IMPORTANCE—FREQUENCY—CAUSES—VARIETIES—DIAGNOSIS—PROGNOSIS—TREATMENT—FISTULA AND SINUS.

Ulceration is molecular death of tissue, or a softening and disintegration of tissue, cell by cell. The result of superficial ulceration is the formation of an ulcer or an open sore, characterized by little or no intrinsic tendency to heal. All ulcers are caused and maintained by inflammation, and continue to exist until the primary cause has been removed or rendered harmless. Ulceration and regeneration are both present in an ulcer. If the destruction of cells exceeds the production of cells then the ulcer grows larger in size; if the two are about equal the ulcer remains stationary; if destruction ceases and repair continues, the ulcer grows smaller and finally heals.

Ulcers are extremely frequent and while they are apparently insignificant lesions they produce much suffering and disability. As will be shown they may be due to different causes. There is no one remedy which will prove efficacious in their treatment and their cure frequently taxes the diagnostic ability and resources of the surgeon. Ulcers are pre-eminently a disease of the poor. When a rich man injures his limb he at once takes the needed rest and applies appropriate treatment. When a poor man is threatened with an ulcer he can not afford to quit work, but continues his occupation. His leg gets worse, but he maintains an upright position until finally the pain compels him to seek relief. Just in proportion to his reluctance to be treated is his demand for a speedy cure. The conscientious practitioner when confronted by such a case will regret if his knowledge is inadequate to give the best attainable results.

Classification of Ulcers. Ulcers are divided into superficial and deep and into acute and chronic. A *superficial ulcer* is one that involves only the upper layer of the skin; *a deep ulcer* is one that extends through the skin and invades the subcutaneous areolar tissue. *An acute ulcer* is one that results from active destructive changes such as gangrenous inflammation. It develops quickly, spreads rapidly and is attended by marked local and general disturbances. *A chronic ulcer* is one that results from chronic inflammation such as tuberculosis. It develops slowly, progresses insidiously, and does not cause much suffering.

Anatomy of an Ulcer. For the purpose of description, an ulcer is said to have a floor, a margin, an underlying or surrounding tissue and a certain shape or size. The floor or base of an ulcer is the depressed central part of the sore. It is usually flat but may be concave. It is studded with granulations which may be sparse, or thickly set; may be small, pink and firm, or large, pale and flabby. The margin or edge of an ulcer is that portion of its surface extending between its floor and the surrounding skin. It may be sloping, vertical or excavated. The underlying or surrounding tissue of an ulcer consists of the cutaneous or areolar structures lying in immediate contact with it. It is usually hard, dense and even cartilaginous from extension of inflammation and aggregation of leucocytes. The shape of an ulcer varies. It is usually round or oval. It may be serpentine or so irregular as to defy description. The size of an ulcer also varies, not only in different cases but in the same ulcer at different times. It may be only the size of the head of a pin, or may involve the entire circumference of a limb.

Causes of Ulceration. As previously stated, all ulcers are due to destructive changes incident to inflammation. The character of this and the resistance of tissue vary widely with constitutional and local conditions, which must therefore be briefly considered.

1. *Constitution.* Certain systemic conditions predispose to the formation of an ulcer by impairing the patient's resistance to infection. If they can be corrected, an ulcer can be permanently healed. If they are incurable, all that can be accomplished is palliation of the local condition. Ulcers develop during the course of certain infectious diseases, such as syphilis, tuberculosis

and leprosy. Others occur from general disturbances of nutrition, such as starvation, exposure and debilitating diseases.

2. *Local.* Certain mechanical injuries such as a blow, or bruise, a burn or scald may produce a wound which undergoing infection will refuse to heal and become converted into an ulcer. Certain disturbances of circulation, such as ischemia from pressure as in a bedsore, or passive hyperemia from obstruction as in a varicose vein may lead to ulceration. Certain defects in trophic nerve influence may so disturb local nutrition as to cause an ulcer, as in "mal perforant" or perforative ulcer of the foot. Finally, malignant growths such as carcinoma may break down and be the seat of chronic ulceration.

Varieties of Ulcer. Ulcers are divided into different groups and designated by names which indicate either their cause, as varicose ulcers, or their clinical behavior as phagedenic ulcers.

1. *The Inflamed or Traumatic Ulcer.* This type is essentially an open wound which has become infected and undergoes ulceration. The granulations are numerous, small, florid, and bleed easily. The surface is covered with a thick yellow pus which is readily wiped off. Pain is not great but the part has a just appreciation of injury. Granulations usually cease to form when the level of the skin is reached, and epidermization begins as soon as ulceration ceases. The indications for treatment are those for ulcers in general.

2. *The Indolent, Weak or Callous Ulcer.* This type is usually the result of inefficient treatment of the traumatic sore, when from any cause regeneration has been delayed and debility has taken the place of normal activity. The granulations are larger, paler and fewer. They contain less blood and are more insensitive. The discharge is thin and serous. The margins are hard and elevated. The surrounding tissues are swollen and discolored from passive congestion. Treatment consists in scarifying or dissecting out the indurated margins, and then applying the treatment for ulcers in general.

3. *The Exuberant or Fungous Ulcer.* Just as a traumatic ulcer may degenerate into an indolent ulcer owing to too little reparative energy, so it may become converted into an exuberant

or fungous ulcer owing to the exercise of a too active effort at repair. An exuberant or fungous ulcer is one in which granulations form so rapidly that the cells can not be converted into mature tissue. As a result the granulations overshoot the surrounding skin and present the picture spoken of by the laity as "proud flesh." Epidermization can not take place until the exuberant granulations are reduced to the level of the skin. The special indication for treatment is to cut down the granulations either mechanically with a knife or chemically with an escharotic. In practical experience nothing so reduces the pride of "proud flesh" as the judicious use of nitrate of silver.

4. *The Irritable or Erethistic Ulcer.* This type of ulcer is characterized by pain which is always considerable and usually excessive. An indolent ulcer does not appreciate an injury; a traumatic ulcer merely acknowledges it; an irritable ulcer resents it. Irritable or erethistic ulcers are sometimes seen on the ankle but usually occur in the rectal region, e. g., fissure in ano. They are usually superficial and involve only the upper layers of the skin or mucosa. They are usually deeper at some point on their floor than at other points. They contain few granulations, are angry dark red in color and covered with grayish film. Their edges are serrated and everted. Discharge is thin, acrid and bloody. Indications for treatment other than those for ulcers in general are rest of the part and excision or destruction by cauterization.

5. *Phagadenic or Gangrenous Ulcer.* This is a type of ulcer due to infection with germs of great virulency characterized by rapid molecular disintegration of tissues and increase in size of ulcerative area. As an example may be cited the chancroid. The phagadenic ulcer is usually irregular in shape. The margins are abrupt and somewhat ragged. The surface is destitute of granulations, of uneven depth and brownish color. The skin around it is red and swollen. The discharge is thin, acrid and bloody. Special indications for treatment are disinfection and cauterization with nitric acid or the actual cautery.

6. *The Varicose Ulcer.* This is a type of ulcer usually found on the leg, due to infection and ulceration of tissue predisposed

to degenerative processes by lowered vitality from passive hyperemia. The pathological changes consist in destruction of the valves in the veins from the weight of the long column of blood, dilatation of the vessels and the production of varicosity. Interference with the flow of venous blood causes an edematous swelling of the limb. Infection follows either from without by injury or from within by local phlebitis. Then comes inflammation, ulceration and the formation of a sore. These ulcers have the characteristics described under the head of indolent, weak or callous ulcers. The essential element in successful treatment is the correction of the passive hyperemia in the limb. This may be effected in some cases by strapping or the use of elastic constriction; in other cases by the prolonged elevation of the limb. The quickest and most permanent cure will follow the excision of the main venous trunks, dissecting out the ulcer and skin grafting the resulting raw surface.

7. *Trophic Ulcers.* This type of ulcer is due to some unexplained interference with the trophic nerve influence in the part which leads to its infection and ulceration; as an example may be cited the perforating ulcer of the foot. Owing to lack of knowledge of the etiology or pathology, treatment is usually symptomatic. Recently stretching of the nerve trunks leading to the part has been tried with apparently beneficial effect.

8. *The Specific Ulcer.* This type of ulcer is due either to certain constitutional diseases such as syphilis, tuberculosis, actinomycocis, leprosy, scurvy, etc., or to local trouble, such as malignant disease. Specific ulcers will be discussed in the lectures on the different diseases which cause them.

Diagnosis of Ulcers. The diagnosis of the cause of ulceration is essential to successful treatment. In some cases it is easy, in others difficult, and in some instances impossible. The clinical history of the patient should be carefully reviewed, the area itself critically examined and if necessary microscopical examination or inoculation experiments made of discharges, or fragments of tissues.

Prognosis of Ulcers. The prognosis of an ulcer depends upon the type of ulceration and the possibility of removing its cause.

It is also influenced by the general health of the patient, his pecuniary ability to take the necessary treatment, and the ability of the attending surgeon.

Treatment of Ulcers. The indications for treatment which apply to all ulcers are to remove the cause, to give the affected part rest, to eliminate infection and to apply appropriate dressings.

1. *Remove the Cause.* If the ulcer be due to mechanical irritation such as the edge of a rough tooth or the corner of an improperly padded splint, the cause should be removed. If the ulcer be due to passive hyperemia from varicose veins the edema should be removed by elevating the limb, and prevented from recurring by the use of bandages or by excising the varicose vein. If the ulcer be due to syphilis or scurvy the cause should be combated by appropriate constitutional remedies.

2. *Mechanical and Functional Rest.* The part the seat of ulceration must be given rest. If the ulcer be on the cornea light must be excluded; if the ulcer be in the stomach, food by the mouth must be temporarily withheld and the patient sustained by rectal alimentation. If the ulcer be on the leg, locomotion must be prohibited. If the ulcer be on the sphincter ani the muscle must be paralyzed by divulsion.

3. *Eliminate Infection.* As ulceration is always due to infection and usually attended by suppuration a thorough preliminary disinfection should be practiced before the application of any of the dressings to be afterwards described. This disinfection should consist of the sterilization, not only of the infected area, but of the entire part on which it is located. This should be accomplished by the usual methods of shaving, scrubbing with hot water and green soap and the use of antiseptic solutions.

4. *Apply Appropriate Dressings.* (*a*) Moist Dressings. After the preliminary cleansing of the wound and adjacent surfaces, the first treatment usually tried is the moist dressing. The method of application consists in saturating a pad of absorbent cotton with the solution selected, applying it to the raw surface and preventing rapid evaporation by covering it with a layer of oil silk. The cotton should be wet as often as it becomes dry, and

should be changed as often as it becomes soiled. The solution employed should not be a strong antiseptic as it would kill cells as well as germs, but it should have an inhibitory action on microbic life. The three that will be found most satisfactory are chloral hydrate solution (chloral hydrate ʒi, water Oij); Thiersch's solution (salicylic acid ʒss, boric acid ʒiij, water Oij); and acetate of aluminum solution (alum ʒvj, acetate of lead ʒixss, water Oij). They may be used either hot or cold and should be employed in conjunction with rest and elevation. Many a rebellious and swollen leg ulcer comes to the surgeon scarred with caustics, gritty with antiseptic powders or filthy with greasy ointments; but few fail to yield when the patient is put to bed, the limb elevated, and the part treated as above described.

(*b*). Dry Dressings. The treatment of ganulating surfaces by dusting them with antiseptic powders has been made undeservedly popular by the advertisements of firms that have proprietary preparations to sell. The powders most frequently employed are iodoform, aristol, dermatol, bismuth, boric acid and oxide of zinc.

In some cases they do good, but in most instances they do harm. Chemically they destroy germs and lessen suppuration; mechanically they destroy embryonal cells and retard healing. When first applied to a wound decided improvement is seen, but continued use is followed by irritation due to absorption of moisture and the formation of crystalline concretions that act as foreign bodies, or broad incrustations that prevent the escape of pus and other wound secretions.

(*c*) Oleaginous Dressings. The use of salves and ointments in the treatment of superficial wounds has fallen into unmerited disfavor. Because before the day of antiseptic surgery they were abused is no reason why they should now no longer be used. Some preparations become rancid and should be avoided; others remain sterile and may safely be employed. Vaseline, lanoline, and castor oil, plain or medicated, will give better results in some cases than any other application. They exert a feeble antiseptic action thus lessening suppuration; they exclude the air thus relieving pain; and they prevent the adhesion of overlying dressings thus saving the embryonal cells from mechanical injury. In extensive burns there is nothing better in the early stages than a 5 per cent mixture of ichthyol and vaseline, and in sluggish granulations, especially of a tubercular character, good will result from the application of a combination of 1 per cent carbolic acid, 5 per cent balsam Peru, and 94 per cent castor oil.

(*d*) Nutritive Dressings. Considerable benefit will sometimes be derived in the treatment of a granulating wound by the use of a dressing that supplies food directly to the formative cells and their offspring. Proliferation is often arrested by starvation, and feeding is the logical remedy. The agent employed should be aseptic, non-irritating, and should contain nutritive material in an easily absorbable form. The preparation that most nearly meets these requiremens is Valentine's Meat Juice. It is sterile, contains no alcohol, is rich in foodstuff, and possesses the proper percentage of sodium chloride. It should be diluted with three-fourths water warmed to the temperature of the body, and applied on cotton in the form of a moist dressing. It does a great deal of good for a short while, but then loses its effect. As soon as pale granulations become pink and healthy it has fulfilled its function, and should give place to some other dressing.

(*e*) Alterative Dressings. Cells, like individuals, sometimes without assignable reason develop disturbances of nutrition requiring alterative treatment. In the management of a granulating wound there is often call for local medication. Experience alone can teach the surgeon the agent to employ and the time and method of its application. Nitrate of silver, mercurial ointment, chloride of zinc, and sulphate of copper are all useful and time honored remedies. Among newer preparations must be mentioned proto-nuclein. Sometimes indolent or foul granulating areas which have defied a half-dozen other lines of treatment improve under its use as if by magic.

(*f*) Protective Dressings. In direct contrast to granulating surfaces that need stimulating or alterative treatment are those that are doing well and only require protection. When the wound is healthy and healing progressing satisfactorily, nothing is more mischievous than meddlesome interference. All that should be done is to avoid infection by cleanliness, and to avoid injury to the newly formed cells by mechanical protection. Cleanliness is secured by changing the dressings as frequently as they become soiled and bathing the wound with normal salt solution. Protection is best accomplished by interposing some impervious material between the granulations and the meshes of the overlying gauze, into which they would otherwise become entangled. The best results follow the use of strips of rubber tissue placed latticewise so as to afford drainage. Rubber tissue is cheap and easily obtained. It can be sterilized by soaking in a solution of bichloride, from which it must be freed before using by washing in sterile water.

(*g*) Proliferating Dressings. When the destruction of skin is so extensive that the normal reparative power is insufficient to cover the granulating area with epithelial cells, recourse must be had to skin grafting. It has long been known that bits of cuticle properly planted on flesh wounds or healthy granulating surfaces would become adherent and grow, thus protecting underlying structures and act as independent foci of epidermization for adjacent tissue. The application of this fact with epithelial cells secured from different sources and applied by various methods has enabled the surgeon to cause quick and certain healing of wounds which otherwise would be slow to close, or perhaps become permanent ulcers.

FISTULA.

A fistula is an abnormal opening between the skin or mucosa and a normal cavity. As examples, an opening between the skin and stomach is called a gastric fistula; an opening between the skin and bladder, a vesical fistula; an opening between the skin and rectum, a rectal fistula, and an opening between the mucosa of the vagina and the bladder, a vesico-vaginal fistula. Fistulæ are caused congenitally by defects in development: pathologically by sloughing from pressure and inflammation and surgically by operative procedures. The treatment of fistulæ consists in freshening the margins of the opening and uniting them by sutures.

SINUS.

A sinus is an abnormal opening between the skin or mucosa and an abnormal cavity. An opening leading from the skin to a cavity formed by a tuberculous abscess in soft tissue or to an osteomyelitic cavity in the center of a bone is a sinus.

A sinus can not be treated *per se*. The only way to cure it is to deal with the cavity which it drains. With the obliteration of the abnormal cavity the sinus will usually close spontaneously.

LECTURE XX.

GANGRENE—DEFINITION — CAUSES — VARIETIES — SYMPTOMS — DIAGNOSIS—PROGNOSIS—TREATMENT.

Gangrene, mortification, necrosis and sphacelus are synonymous terms used to designate the death of tissue *en masse*. English writers usually employ the word necrosis to designate death of bone, and apply the terms gangrene, mortification and sphacelus to death of soft tissue. Of late years a further distinction has been drawn, necrosis being applied to death in an internal structure where, owing to the absence of saprophytic infection, putrefactive changes do not follow, gangrene and mortification being applied to death of parts of the body exposed to the atmosphere, where owing to saprophytic infection, the tissue soon undergoes putrefactive changes.

CAUSES.

Gangrene is not a disease, but is a condition which may result from general or local causes or a combination of both. Among the general causes may be mentioned starvation, old age, alcoholism, debility from overwork and bad hygienic surroundings; also diabetes, nephritis, syphilis, scurvy, typhoid fever, and other diseases which lessen the resistance of tissue and lower the vitality of the body as a whole. The local causes may be classified under four heads:

1. *Interference with Arterial Supply.* This may be due to traumatism where the injury results in the division or obliteration of a main artery, as in the case of a stab wound of the vessel; or it may be the result of pressure, as in bed sores due to leaving the patient too long in one position; or from overstretching of the tissues, as in death of a flap after a plastic operation. It may follow the constriction of the lumen of an artery as in

gangrene of the leg following ligation of the external iliac, or it may result from thrombosis and embolism, the coagulated blood obstructing the vessel and arresting the current. This is also the cause in cases of gangrene due to disease of the arteries, such as arterio-sclerosis, which gradually lessens their lumen, or obliterative spasm of the muscular coat incident to the prolonged administration of ergot.

2. *Interference with Venous Return.* This is as surely fatal to the vitality of a part as is the arrest of the arterial supply, and results from practically the same conditions. It may be due to an injury which partially or completely divides the vessel, to pressure from a tight bandage, splint or plaster cast; to ligation, as is sometimes seen in gangrene of the arm following ligation of the subclavian vein; or it may be due to thrombosis or embolism blocking the large venous channel from some region unprotected by collateral vessels which remain unobstructed.

3. *Interference with Trophic Innervation.* For tissue to thrive it must not only have proper arterial supply and venous return but it must also have trophic innervation. Thus, there is neuropathic gangrene seen after fracture of the spine, due to functional disturbance of the so-called "trophic nerves," and there is also a symmetrical gangrene called Reynaud's disease, due to spasm of the vaso-constrictors, brought about by reflex action.

4. *Direct Action of Destructive Agents on Tissue.* There are certain causes which, independently of their action upon the arteries, veins or nerves, produce gangrene by direct destruction. Among these may be mentioned mechanical injury, such as is seen when an extremity is crushed beneath a car wheel; or the action of heat and cold, as in the case of a burn or a frost bite; strong chemicals as nitric acid or caustic potash; and finally and most important of all, acute inflammation may result in gangrene by the direct action of the toxins produced by the bacteria. As an illustration may be cited the dead connective tissue which constitutes the core of a boil, or the more extensive death of tissue seen in the malignant edema of Pirogoff.

VARIETIES OF GANGRENE.

There are two varieties of gangrene, the dry and the moist, which present striking contrast to each other in physical appearance. It must be remembered, however, that there are many gradations between the two extremes, and sometimes the two types may be seen side by side in the same patient.

Dry or Chronic Gangrene. Dry gangrene usually develops slowly as the result of the gradual diminution of blood supply to the part. The fluid in the tissue has time to be removed by natural drainage or by evaporation, thus leaving the part hard and shriveled. Decomposition takes place to only a limited extent, the skin becomes black and wrinkled, and there is but slight disturbance seen in the adjacent living tissue. Usually a line of demarcation forms between the dead and living tissues. Often there are no constitutional symptoms.

Moist or Acute Gangrene. This develops quickly, usually as a result of sudden interference with arterial supply or venous return, and the tissue involved is full of fluid. The part becomes swollen, the skin mottled and discolored and blisters form. These rupture and evidences of decomposition and putrefaction are soon seen. Gases develop, a foul discharge is noted, and the tissues break down into a putrid mass. There is not often a line of demarcation between the diseased and healthy tissue, and usually constitutional symptoms are marked.

SYMPTOMS OF GANGRENE.

The general symptoms of gangrene are due to the absorption of the products of decomposition. In dry gangrene there is but little septic intoxication, while in moist gangrene there is usually a chill, followed by high fever, rapid, irregular pulse, shallow respiration, cold, clammy skin, frequently terminating in delirium, coma and death. The local symptoms are more interesting and of greater diagnostic importance.

Pain. This may be practically absent at all stages of the process, for in senile gangrene, there is no pain, but merely the presence of a numbness. Again, the beginning of the process may be indicated by sudden, agonizing pain, as is seen when an embolus lodges in the bifurcation of an artery and acute anemia follows. Finally, gangrene may be indicated by the sudden cessation of pain, as is seen in strangulated hernia or a bad case of appendicitis when death of the part ensues.

Tenderness. As long as the part is tender it is not necrotic. Absence of sensation is a sign of death. Often the best way to convince the patient or his friends of the necessity of an amputation in gangrene of an extremity is to stab the part with an aseptic needle.

Temperature. In gangrene following an acute inflammation, the local temperature for a time is high, but with cessation of circulation, it soon falls below normal.

Pulse. The presence of pulsation in an artery shows that circulation is still going on; its absence shows that gangrene is either threatened or actually in existence. When an artery is suddenly obstructed by an embolus, or more slowly occluded by degenerative changes in its wall, the presence or absence of pulsation in its terminals is a point of great diagnostic importance.

Swelling. In dry gangrene the part becomes hard and shriveled and is said to be mummified. In moist gangrene the tissue becomes distended with fluid and with the gases of putrefaction, and is frequently swollen to twice its original size.

Emphysema. In certain cases of moist gangrene there is the production of considerable quantity of gas in the tissue, which gives crepitation to the palpating finger. This usually indicates a rapid and grave type of the disease, and is due to infection with aerogenic bacteria.

Color. If a large artery is suddenly obstructed by an embolus or ligature, its area of distribution presents at first a preternaturally pale appearance. As soon as decomposition begins, the red corpuscles of the blood undergo disintegration, and the coloring material is diffused through the dead tissue, which becomes blue and finally black. This is due to purely chemical changes, and is supposed to be the result of a combination of hydrogen sulphide with hemoglobin.

Condition of the Tissues. In dry gangrene the tissues, owing to evaporation of fluid, become firm and hard. In moist gangrene, owing to the presence of excessive fluid, they become soft and friable. In the first there is no discharge, but in the second a bloody, fetid fluid escapes from the dead tissue.

Odor. There is little or no odor to dry gangrene, but in moist gangrene there is an unbearable stench. The odor has the same characteristics and is due to the same chemical changes as that incident to decomposition of organic material under other conditions.

Line of Demarcation. In some cases gangrene will progress to a certain point, then be arrested, and a line of demarcation will be formed between the dead and living tissue. In septic gangrene this line marks the limit of the area of infection, while in aseptic gangrene it indicates the point where the blood supply is adequate for nutrition.

Elimination of Necrotic Tissue. Frequently there is spontaneous removal of the gangrenous part by absorption or encapsulation if the area is small, or by granulation, suppuration or liquefaction if the area is large. When this takes place repair begins at the line of demarcation, and nature, by the various processes of regeneration, endeavors to correct the injury sustained.

DIAGNOSIS.

The diagnosis of gangrene is usually so easy that it can be made by sight and smell. The absence of circulation and of sensation, the subnormal temperature and discoloration, the mummification in the dry type and the rapid putrefaction in the moist variety, leave no room for doubt. There are occasionally cases, however, such as when a surgeon opens the sac of a strangulated hernia, when the question whether gangrene is threatened or in existence is one of paramount importance and difficulty. In such cases, when in doubt whether to excise the loop of bowel or return it to the abdominal cavity, it will be better not to do either, but to protect it with gauze wrung out of hot saline solution, and wait to see whether circulation will be restored or not.

PROGNOSIS.

The prognosis in a case of gangrene is dependent on the nature of its cause, the rapidity of its progress, the presence or absence of complications, and the age and general condition of the patient.

TREATMENT.

The special indications for treatment of the various types of gangrene will be discussed in the next lecture. There are certain general principles, however, which apply to them all, which will be now considered. When gangrene threatens but is not actually in existence, prophylactic measures must be at once applied. The most important of these is an attempt to remove the cause. If it be due to pressure from a bandage or immobilizing dressing, take it off. If caused by decubitus, see that the patient's position in bed is changed at frequent intervals. If due to constriction at a hernial ring, divide the constriction. If it results or is threatened by the swelling of acute inflammation, relieve the tension by prompt incision. If incident to a constitutional disease such as diabetes, endeavor to correct this by appropriate systemic treatment.

The second indication is to favor collateral circulation, and thus endeavor to supply adequate nutrition to the part and avert the threatened gangrene. If the main artery of a limb is obstructed, it should be placed in a horizontal or slightly elevated position, and kept warm by the external application of dry heat. If the premonitory symptoms of senile gangrene develop, the danger should be combated by increasing the circulation in the part by massage and electricity, emptying the veins several times a day by stripping the limb from the toes or fingers towards the trunk.

The third indication is to prevent infection. When gangrene threatens, the part should be rendered aseptic in the same manner as it would be prepared for a surgical operation, and the parts protected against infection by putrefactive bacteria by a dry absorbent antiseptic dressing.

If gangrene develops, owing to the neglect of, or despite the use of the foregoing measures, then becomes necessary the consideration of the curative treatment. This consists in the administration of remedies to sustain the strength of the patient, and in operative procedures for removal of the dead tissue. Pain, should be relieved by morphine. If fever is high, it should be combated by local measures to prevent absorption of phlogistic products, and by the use of cold sponging or alcoholic baths. Most patients suffering with gangrene are feeble and debilitated, and the use of antifebrin, antipyrin, veratrum viride and similar drugs is strongly to be condemned. Strychnine, digitalis, quinine and iron are indicated, but the surgeon's main reliance to sustain strength should be the use of alcoholic stimulants and nutritious food.

The question of surgical intervention for the removal of gangrenous tissue is one of grave importance. The success of operations performed after the formation of the line of demarcation when compared with the results of those performed before its development led the older surgeons to advocate waiting until nature indicated the site of the incision. In some cases, especially in dry gangrene, this is good practice, but in other cases, especially, for example, in the progressive moist variety, to wait for the line of demarcation would be to wait for something which will never develop. In dry gangrene, if there are no grave septic symptoms, the surgeon should wait until the dead tissue separates from the living, when frequently, simply with scissors and bone pliers, he can cut the more resisting structures and allow the resulting surface to heal by granulation under a simple dressing. Occasionally a more formal operation is indicated in order to secure flaps, which will unite by primary intention and thus shorten the time of convalescence and secure a more satisfactory stump.

In moist gangrene, where there are symptoms of septic intoxication, early and radical operation gives the only chance for life. The more acute the symptoms and the more rapid the progress of the gangrene, the greater should be the distance of the amputation from the dead tissue. If the gangrene be due to obstruction of a large vessel and an ascending thrombosis, the amputation should invariably be made at a point where the vessels are not occluded. The application of an Esmarch's bandage to the extremity is strongly to be condemned, as it forces toxic products into the general circulation. The limb should be held in an elevated position by an assistant for a few moments, and the tourniquet then applied. The condition is a desperate one, and while the work should be done properly, no unnecessary time should be sacrificed in the accurate coaptation of structures or the artistic application of dressings. As the tissues are always edematous and there is more than the usual danger of infection, the wound should be thoroughly drained. If, as is unfortunately often the case, gangrene recurs in the stump, a second operation gives but poor promise of better success, and usually all that can be done is to remove the stitches, expose the entire cut surface, and treat with moist antiseptic dressings.

LECTURE XXI.

GANGRENE (CONTINUED)—MICROBIC GANGRENE—SENILE GANGRENE—DIABETIC GANGRENE—DECUBITUS GANGRENE—X-RAY GANGRENE—CARBOLIC ACID GANGRENE—NOMA—HOSPITAL GANGRENE.

MICROBIC GANGRENE.

Microbic gangrene is a virulent moist gangrene due to infection with certain aerogenic bacteria. It is sometimes spoken of as progressive gangrene, traumatic gangrene, emphysematous gangrene, or malignant edema. It is characterized by rapid extension, by the formation of gas in the dead tissue, and by constitutional symptoms of acute sepsis. It is due to the combination of trauma and infection. The injuries are usually those which open up large areas of connective tissue, such as a mutilating railroad accident, compound fracture or an operation for radical removal of the breast. It may follow trivial abrasions or even a needle puncture. The micro-organism usually found associated with the disease is the *bacillus aërogenes capsulatus*, although other germs have been isolated.

The symptoms of this form of gangrene usually develop in a few hours. There is often a chill, followed by rapid failure of the pulse, irregular respiration and cold extremities. The patient is irritable and anxious, soon becomes delirious, and then goes into a stupor. The local symptoms consist in swelling and a dusky redness about the wound, the adjacent skin soon becoming brownish, then green, and finally black. Blebs form, containing foul and bloody fluid; the gangrene progresses rapidly, often extending in finger-like prolongations. Red lines mark the course of the lymphatics, and the lymph nodes enlarge. If an incision is made, there is escape of offensive fluid, and gas will bubble through the opening. The odor is horrible. The mortality is stated at about 55 per cent.

Treatment. An ounce of prevention is worth a pound of cure. The condition should be guarded against by thorough disinfection of accidental wounds, and the application of the recognized rules of asepsis in surgical work. When progressive gangrene does develop, the only chance for the patient's life consists in an early amputation if the part involved be an extremity, or in multiple free incisions, followed by copious antiseptic irrigations and moist dressings if the disease be so located that it cannot be radically removed. No time should be lost in waiting for the line of demarcation in an extremity, but an amputation done as soon as the condition is recognized, the incision being made as far as possible from the diseased tissue. The flaps should be brought loosely together, with abundant provision for drainage. In progressive gangrene of the trunk, the incision should be made freely, not only through gangrenous tissue, but through adjacent structures. It has been suggested that irrigation with solutions of peroxide of hydrogen or permanganate of potash be practiced owing to the effect of the nascent oxygen in these substances on anaërobic bacteria.

SENILE GANGRENE.

Senile gangrene is a form of dry gangrene occurring in old people, usually beginning in the toes and involving the foot and leg, but sometimes seen in the upper extremity. It is due to degenerative changes in the arteries, causing diminution of their lumen, and finally complete obstruction by thrombosis. Arterio-sclerosis was at one time thought to be characteristic of old age, but it is now known that it often occurs in early or middle life. The French have a saying that a man is as old as he feels; the English paraphrase it by saying that a man is as old as his arteries. Work, worry, women and whiskey often cause premature senility, and as a result we sometimes see senile gangrene in a man of forty.

The premonitory symptoms consist in coldness and numbness and a tingling sensation in the foot, the patient stating that he feels as if his shoe was stuffed with cotton. The skin is bluish and mottled, and the pulsation in the large arteries weak or absent. There is frequently a cramp in the leg, due to anemia of the muscles, and this may cause a characteristic limp. When senile gangrene actually develops, it usually begins on the great toe at the site of some trifling lesion; the skin becomes red, purple and then black in color, the toe becomes shriveled and hard—in other words, mummification takes place. The gangrene slowly extends to the base of the toe, and may involve the foot or the leg itself. There is usually spontaneous arrest and the formation of a line of demarcation. Unless infection occurs, there are practically no constitutional symptoms.

Treatment. The prophylactic treatment consists in giving the part complete rest, in favoring collateral circulation by elevating the limb and keeping it warm, and in stimulating the circulation by electricity, hot and cold douches, and gentle massage. It is also important to disinfect the skin to prevent infection should actual death ensue. When senile gangrene develops, the necrotic tissue should be kept well dusted with iodoform or some other antiseptic powder, and the patient's general health sustained by stimulants, food and tonics, until nature indicates the site of amputation. To operate too soon means unnecessary loss of limb, while to wait too long invites infection and disastrous results. In favorable cases an amputation may be performed through the line of demarcation with a few snips of a pair of scissors. Should the disease continue to advance, or septic symptoms develop, a prompt amputation should be performed at the lower third of the thigh.

DIABETIC GANGRENE.

Diabetic gangrene is a form of gangrene which often develops spontaneously or after trifling injury or operation, in diabetic patients. It has long been observed by clinicians that furuncles, carbuncles and gangrenous inflammations are frequent complications of diabetes. It was at first thought that this was directly due to the presence of sugar in the blood. It is now believed that the sugar is only an indirect cause, favoring the development of arterio-sclerosis, and predisposing to bacterial infection. Whatever theory is accepted, the practical fact remains that patients with diabetes easily develop gangrene of the progressive variety which can only be controlled by measures which eliminate sugar from the blood.

The symptoms of this type of gangrene are not marked by any peculiarities, consisting simply in the death of tissue, which may undergo mummification, or may soften, putrify and break down. The progress at first is usually slow, but it is steady and persistent, and may at any time become rapid. The constitutional symptoms vary with the nature of the case and are added to those of diabetes.

Treatment. A patient known to be the victim of diabetes should be actively treated for this disease. Every individual who develops gangrene should have the urine examined to see if it contains sugar. Before all operations, the urine of the patient should be examined for sugar, whether he is suspected of having diabetes or not. If sugar is found, the operation should be postponed until it disappears or is reduced to a minimum. When diabetic gangrene develops, it is best not to operate until the patient has, for some days, been on a strict antidiabetic diet. Occasionally the urgency of the case is such that an immediate operation has to be done, but almost invariably there will be recurrence of gangrene in the tissues about the incision. By a rigid diet from which all starches and sugars are excluded, the vitality of the tissues is greatly improved, until finally a point is reached at which resistance is sufficient to check the advance of the gangrene. The line of demarcation then forms, and the operation may be performed with fair assurance of satisfactory repair, provided the most rigid aseptic precautions are observed and active treatment of the constitutional disease is kept up.

DECUBITUS GANGRENE.

Decubitus gangrene is a form of the affection seen during the course of protracted exhausting illness, due to compression of the soft tissues between the mattress on the one hand and the bony skeleton on the other. The necrosis usually develops over the sacrum, hips, shoulder blades or heels, and is commonly termed a bed-sore. The condition is especially likely to occur in the victims of continued fevers attended by emaciation, such as typhoid, is sure to develop after trophic diseases or injuries to the spine, and is common in patients suffering with diabetes or nephritis. The primary cause is pressure and the resulting ischemia, to which is later added infection, resulting in inflammation and ulceration.

The symptoms are a tingling sensation, followed by a dusky redness of the skin, which later becomes purplish and finally black. A slough forms, which separates, leaving a ragged ulcer. This may remain small in size, but often extends rapidly in circumference and depth. Frequently bone is exposed, and if on the sacral region, the spinal canal may be opened and death result from an ascending meningitis.

Treatment. Prophylaxis is all important, and consists in keeping the skin clean, dry and free from long-continued pressure. No patient should be allowed to remain in one position more than three hours. Sheets should be kept free from wrinkles and changed often. Bed-crumbs should be promptly removed, and maceration of skin from contamination with urine and feces should be prevented. The patient should receive regular sponge baths and the back should be rubbed with alcohol, thoroughly dried, and dusted with talcum or zinc stereate powder. When necrosis of the skin threatens, pressure should be removed by the use of fenestrated rubber cushions or by rings made with cotton; in bad cases an air or water bed should be employed. When gangrene actually occurs, the slough should be clipped away, and the sore disinfected with antiseptic solutions. It should then be treated either with dusting powders, moist antiseptic dressings, or a mixture of carbolic acid, balsam of peru and castor oil, as previously outlined in the lecture upon the treatment of ulceration.

GANGRENE FROM ERGOT.

This type of gangrene may be due to the intentional long continued administration of ergot, but is commonly seen as a result of eating bread made from "spurred rye." An epidemic occurred in 1816, in France, and upon investigation it was found that the bread used by the peasants contained 10 per cent of ergot. The action of the drug is through the vasomotor system, producing tonic spasm of the muscular coats of the arteries, thus diminishing their lumen and lessening the quantity of blood conveyed to the tissues to which they are distributed.

The symptoms consist in digestive disturbances, such as vomiting, diarrhea and abdominal pain, followed by dizziness, headache, disorders of vision, and terminating in tingling, numbness, coldness and cyanosis of the extremities. Finally there is gangrene, usually beginning in the fingers or toes. It is of the dry variety, progresses slowly, and usually terminates by the formation of a line of demarcation.

The treatment consists in immediate withdrawal of the drug and dealing with the local conditions practically as in the case of senile gangrene.

GANGRENE FROM FROST-BITE.

The general symptoms produced by cold consist in a lassitude and intense desire to sleep, which often forces the individual, against his judgment, to lie down and rest. The local symptoms consist in stimulation of the circulation, causing redness, which is soon followed by a spasm of the arteries, with a resulting anemia and pallor of the skin. There is often severe pain, but this disappears when the part becomes actually frozen. Swelling soon occurs, the tissues fill with venous blood, and blisters form. When they break, necrotic tissue is seen at their bases. If the frost-bite is not severe, complete recovery usually takes place. Sometimes damage to the blood vessels results in disfiguring hyperemia, and occasionally discolored and sensitive patches, known as chilblains, will be seen. When freezing is more severe, gangrene results, and a toe, finger or entire limb may be lost. Unless there be infection, a line of demarcation forms and the dead tissue will separate spontaneously, leaving an ulcerated surface which heals slowly. Gangrene from cold closely resembles senile gangrene, although it develops more rapidly.

Treatment. A person insensible from cold should not be suddenly put into a warm room, owing to the danger of congestion of internal organs. Clothing should be removed and the body rubbed, first, with cold, wet cloths, then with bare hands, and finally external heat and internal stimulants cautiously used. Efforts at resuscitation should not be abandoned even though there be no response for several hours.

The local treatment applied to a frozen part is to rub it with snow or with cloths wrung out of ice water, then with the bare hands, and finally, when there is evidence of returning circulation, cover the part with absorbent cotton and allow it to become warm through the heat of the body. When gangrene develops, amputation as a rule should not be performed until the line of demarcation forms. In the case of chronic lesions such as chilblains, relief from symptoms has been secured by baking the part affected in hot-air ovens, or treating by artificial hyperemia according to Bier's method.

CARBOLIC ACID GANGRENE.

Patients who are treated with moist carbolic dressings, and surgeons and nurses, whose occupation brings them in contact with the drug, not infrequently develop gangrene. Strong carbolic acid solutions are apparently less likely to cause the trouble than are weaker ones, since by concentrated acid there is produced a superficial necrosis which prevents absorption. The drug acts either by stimulating the vaso-motor nerves, causing contraction of the arterioles, or by direct chemical action upon the tissue.

The symptoms are, first, a tingling numbness, with, later, loss of sensation; the skin at first is white, and afterwards becomes yellow, gray and black. Finally the toe or finger becomes hard, shriveled and gangrenous.

Treatment. To prevent the possibility of the occurrence of this form of gangrene, do not indiscriminately use carbolic acid solutions, but employ less dangerous antiseptics. If a burn is accidentally inflicted by carbolic acid, immediately neutralize it by the application of alcohol. When only the skin is gangrenous, the part may be ultimately restored by grafting. If the entire extremity is dead, amputation is necessary, although it may usually be delayed until the line of demarcation forms.

NOMA OR CANCRUM ORIS.

This is a rare form of gangrene occurring in children from three to ten years of age, who have been subjected to bad hygienic conditions and recently suffered some long and debilitating illness. It usually begins as a livid spot on the inner side of the cheek, the discoloration soon showing on the skin of the face. The area rapidly becomes necrotic and an opening develops into the mouth, which through a foul and offensive discharge takes place. The process may extend to the gums, causing loss of teeth, or to the maxilla, causing necrosis of bone. The general symptoms are those of grave sepsis. The prognosis is bad, 75 per cent of cases being fatal within a week or ten days.

Treatment. The mouth of children suffering from debilitating illness, especially measles, should be kept scrupulously clean, and an ulcer, if detected, should be thoroughly cauterized with nitrate of silver or carbolic acid. If gangrene develops the entire area should be removed with the knife or actual cautery. If recovery follows, the resulting defect can be corrected by a plastic operation.

HOSPITAL GANGRENE.

Hospital gangrene was once a frequent complication after accidental or intentional wounds, but has now been completely banished from surgical practice by the use of aseptic and antiseptic measures. It was unquestionably due to infection, but the germ has never been isolated, as the modern bacteriologist has had no chance to study the disease. The last serious epidemic and the one usually referred to in text books, occurred in 1863 among the Union soldiers in the Confederate prison at Andersonville, Ga. At this point 35,000 men were confined under most depressing conditions, with scant food and clothing, and the most horrible hygienic surroundings. Small injuries received, such as wounds from splinters, blisters from the rays of the sun, or even scratches from finger-nails or bites of insects, were followed by extensive and often fatal gangrene. It was impossible to separate the well from the infected, and in one month the death roll amounted to 3000 men. At the close of the war, the Federal Government captured the commanding officer of the prison, tried him by court martial and executed him. Recently a camp of Confederate Veterans has erected a monument, with an inscription vindicating his memory. There is no question of the fact that the local conditions were so bad as to defy description. There is, however, question as to who was responsible, the Confederate Government which did not have the means or supplies to correct the evil, or the Federal Government, which was petitioned to either exchange prisoners or else to send drugs, dressings and provisions, to be dispensed under the personal supervision of their own medical officers, and which declined to accept either proposition.

Hospital gangrene occurred usually in one of two forms:

1. *The Ulcerative Form.* The wound became unhealthy in appearance and the seat of light gray or dark red patches. These would soon break down, run together and form an ulcer. The skin became disintegrated, and the edges of the wound appeared as if they had been bitten out. The surface was discolored and of a brownish hue, and the discharge thin, streaked with blood, and of a foul odor.

2. *The Pulpy Form.* In this form the wound became enormously swollen and changed into a dirty gray or greenish mass of putrefying, spongelike tissue. The edges of the wound would be raised, everted, and of a deep red or purple hue. The swollen membrane soon began to putrefy, but would not readily separate. There was a discharge of gas and sanious fluid, with separation of gelatinous sloughs. In both forms, as the infection advanced, no tissues were spared. Muscles and fascia were eaten away,

articulations opened, and bones became necrotic. Finally a large vessel was reached and profuse hemorrhage occurred. The mortality was from 18 to 80 per cent.

The treatment consists in hygienic measures to prevent the occurrence of the disease, and in the isolation and heroic disinfection of such cases as develop. Cauterization with nitric acid or the hot iron, irrigation of the wound with peroxide, and subsequent dressing with iodoform or other antiseptics, coupled with stimulants, tonics, good food and abundance of fresh air, give the best chance for recovery.

LECTURE XXII.

SHOCK — HISTORY — CLINICAL PICTURE OF A TYPICAL CASE— CAUSES — PATHOLOGY — SYMPTOMS — TERMINATIONS — DIAGNOSIS — PROGNOSIS — TREATMENT — QUESTION OF OPERATING DURING SHOCK.

It has long been known that patients who met with accidents or underwent operations not of themselves necessarily fatal, frequently died without apparent cause. It is only within the last century that it has been known that these cases died of shock. As soon as the condition was recognized, it was studied both clinically and experimentally by the leading men of the profession, and the literature of the subject is now a large one.

The writers of the past generation had a clear conception of the causes and symptoms of shock, but they did not understand its nature, and hence the methods of prevention and cure were inefficient and unscientific. Within the past decade, Crile, of Cleveland, a leader in the new school of surgical physiology, has satisfactorily worked out its pathology, and the publication of his recent articles has revolutionized the practice of the profession in dealing with the condition. There are yet some apparently contradictory facts to be explained, and certain problems to be more fully elucidated, and, consequently, it will probably be best to introduce the subject by giving a clinical picture of a typical case.

TYPICAL CASE.

A patient who has been subjected to a mutilating, and perhaps bloody, operation, is carried to the ward. When placed in bed, he makes no effort to move or speak, but lies staring at the attendants. His face is white and pallid, his features pinched, and his eyes are sunken in their sockets and encircled by black discoloration. He complains of no pain, expresses no anxiety, and his mental attitude is one of complete indifference. His skin is cold, and bathed in a clammy sweat. His lips and nails are blue, his pulse is rapid and threadlike, or may be imperceptible at the wrist. His respiration is shallow, sighing and irregular. A thermometer placed in the rectum shows his temperature to be subnormal. There is no muscular paralysis, but the patient lies perfectly still and is disinclined to move. There is no unconsciousness, but he does not speak unless spoken to, and then answers questions in slow monosyllables. If reaction does not follow, the pulse gets weaker and finally disappears; the respiration becomes more shallow, and the skin clammy and colder, and "this momentary pause in the act of death is soon followed by the grim reality." A postmortem examination shows no pathologic change to explain the symptoms.

CAUSES OF SHOCK.

1. *Loss of Blood.* This is by far the most frequent cause of shock. In fact, a sudden hemorrhage produces symptoms so identical with shock that it is difficult to distinguish the two, and a diagnosis can often only be made by the history of the blood findings. The more rapid the loss of blood, the more severe the shock and the less the chance of recovery.

2. *Loss of Heat.* The abstraction of body heat by operating in a cold room, exposing the abdominal or other viscera to the air, or wetting the clothing of the patient with solutions which, while warm at the time, soon become cold, all strongly tend to produce shock.

3. *Loss of Time.* An operation which, if quickly done, would produce no appreciable degree of shock, if unduly prolonged frequently is followed by alarming symptoms. This is partially due to the fatigue, exposure and prolonged anesthesia to which the patient is subjected, but is also due to the continued irritation of the brain and spinal cord by stimuli from the field of operation. Ether and chloroform prevent the appreciation of pain, but they do not protect the nerve centers whose exhaustion causes shock.

4. *Mechanical Injuries.* These vary in degree from rough handling of tissues by the surgeon to a compound dislocation or crushing injury of a limb by an accident. The various tissues and organs of the body have a shock producing power in proportion to their nerve supply, and, consequently, the degree of shock will depend not only on the severity of the trauma, but also on the sensory innervation of the part. Injuries to certain regions of the body are especially likely to be followed by shock, such as a blow on the testicle, in the pit of the stomach, or at the angle of the jaw.

5. *Burns.* The action of intense heat on the nerve terminals of the skin often produce profound shock. Mummery has pointed out that burns of the first and second degree produce more shock than burns of the third degree. This is due to the fact that, in the first case, the nerve terminals are exposed and irritated, whereas, in the second, they are destroyed. A burn involving more than one-half of the surface of the body usually causes death from shock.

6. *Perforating Injuries.* Rupture of the gall bladder, perforation of a gastric, duodenal or typhoid ulcer, or a rapidly fulminating case of appendicitis, resulting in the discharge of irritating fluids into the peritoneal cavity, frequently causes sudden and profound shock. It is supposed that the pus, gastric juices or intestinal contents act on the peritoneum as heat would act on the skin.

7. *Mental Emotions.* The psychic condition of the patient undoubtedly influences the occurrence of shock. There is no reason to doubt that violent emotions, such as intense fear or terror, can exhaust the nervous power and produce the same results as a physical injury. A case is on record where a man who had been sentenced to death by bleeding actually died on hearing water trickle into a basin, which he supposed to be blood issuing from his veins. Another case is quoted where a man fainted and died, under the impression that an operation was in progress, when the surgeon was, in fact, only tracing with his nail the line of incision on his perineum. Brunton quotes the case of a janitor of a college who had rendered himself obnoxious to the students. One night they carried him to a lonely place, and having dressed themselves in black, tried him for his life.

He at first affected to treat the incident as a joke, but was assured by the students that they meant it in real earnest. He was found guilty and was told to prepare himself for death. He was blind-folded and made to kneel before a block, and was struck on the back of the neck with the edge of a wet towel. He fell to the ground, and, to the astonishment and horror of the students, they found that he was dead from shock.

In addition to the foregoing exciting causes of shock, there is considerable influence exerted on its production by the age, sex, temperament, mental condition, and general health of the individual. The young and the old are more likely to suffer from shock than those of middle years. Women, as a rule, stand injuries and operations better than men. Those of sanguine or nervous temperament suffer more from shock than the lymphatic. The chronic invalid usually stands surgery better than a robust man, and a patient who comes to the operating table confident and hopeful is less likely to develop shock than one possessed with gloomy forebodings as to the future.

PATHOLOGY OF SHOCK.

Shock is stated by Crile to be essentially due to an abnormally low blood pressure. The normal blood pressure is dependent on three factors: First, a proper force of heart beat; second, a proper rate of heart beat; and third, a proper peripheral resistance. The effect of variation of these factors may be stated in several definite laws:

1. The blood pressure must vary with the *rate* of the heart, if the heart strength and peripheral resistance remain constant.
2. The blood pressure must vary with the *strength* of the heart, if the heart rate and peripheral resistance remain constant.
3. The blood pressure must vary with *peripheral resistance*, if the heart strength and heart rate remain constant.
4. The blood pressure may be normal if one or two factors increase, while one or two factors decrease.
5. If all three factors increase, we must have a proportionate increase in blood pressure.

6. If all decrease, we must have a proportionate decrease in blood pressure.

7. All three factors are controlled by the nervous system.

Shock is due to irritating or painful impulses which are produced by accidents or operations. These impulses act on the centers of the brain and cord, first causing stimulation, but later resulting in exhaustion or paralysis. They may be of such degree as to at once overwhelm the centers, or they may produce the same result slowly, by acting continuously for a considerable period of time. Crile believes that shock is invariably due to paralysis of the vaso-motor centers and a consequent loss of peripheral resistance. Howell believes that it may also be due to feeble heart action. Accepting the latter conclusion, as seems borne out by clinical facts, shock may be defined as a condition characterized by long continued low blood pressure, due either to partial or complete paralysis of the vaso-constrictor centers and consequent lack of peripheral resistance (vascular shock), or to alterations in the rate and force of the heart beat, due to partial or complete loss of activity of the cardio-inhibitory center (cardiac shock).

Whether the low blood pressure be due to vascular or cardiac causes, the result is the same. The face becomes blanched, the skin pallid, the temperature subnormal, the pulse weak and thread-like, the respiration shallow and sighing, the muscular power impaired and cerebration blunted. These changes are due to lack of sufficient circulation to maintain normal physiological function. The blood does not flow freely through the arterial system, but accumulates in the dilated venous trunks, especially in the abdominal region. In other words, the arterial system bleeds into the dilated venous system, and, as the old writers put it, the patient may bleed to death in his own vessels.

SYMPTOMS OF SHOCK.

1. *Facial.* The expression of the face is frequently so altered that it is difficult to recognize the individual. The pupils are but slightly changed, but the eyes are sunken in their sockets,

the lids half closed, and the areolar around them darkened. The nose is small and shirveled, and the lips are thin, pale and usually parted.

2. *Cutaneous.* The skin has a sickly pallor, and the surface of the body is cold and bathed in clammy sweat. The fingers and nails are of a bluish color, and the skin on the palmar aspect of the hands lies in loose folds.

3. *Mental.* The patient is not unconscious, but the mental faculties are less acute than normal. He complains of no pain, expresses no anxiety as to his future, and shows no interest in what is being done for him. If asked a question, he will reply intelligently, but slowly and with effort.

4. *Muscular.* There is no paralysis, but reflexes are diminished, and the voluntary and involuntary muscular systems are greatly relaxed. The patient lies in the posture in which he is put, and does not voluntarily change his position or move his limbs. There is frequently loss of control of the sphincters, with involuntary discharge of urine and feces.

5. *Respiratory.* Respirations are, as a rule, quickened, irregular and shallow. In grave cases there is gasping, although air hunger is never as marked as in pure hemorrhage.

6. *Circulatory.* The condition of the pulse varies with the degree of shock. It is usually small, thread-like, and, at times, imperceptible. The strength of the pulse is an important guide to the surgeon in making a prognosis.

7. *Temperature.* The temperature is subnormal, a thermometer placed in the rectum frequently registering as low as 95° or 96° F. Much lower temperatures are reported from observations taken in the axilla, but these are not reliable.

TERMINATIONS.

Shock may terminate in either of two ways:

1. *Reaction.* If recovery ensues, the patient begins to move about in bed, turns on his side, and perhaps vomits. The pulse gets fuller and slower; the respiration deeper and more regular; the skin warmer and dryer, until finally there is a return of the system to its normal condition.

2. *Death.* In fatal cases of shock, the pulse grows weaker and finally disappears. Respiration becomes shallow and irregular. The skin grows colder; the patent gradually becomes unconscious; the sphincters relax, and he slowly expires.

DIAGNOSIS OF SHOCK.

The diagnosis of shock, at the present time, can not be made with scientific accuracy and must be based on the personal experience of the surgeon. It is made on the symptoms above described, especially the weak, rapid pulse, the cold, pallid skin, the subnormal temperature, and the curious condition of the mental faculties.

The differential diagnosis between shock and hemorrhage, syncope, fat embolism, hysteria and other conditions with which it may be confused, is sometimes difficult. In hemorrhage, the symptoms are usually gradual in onset and progression. The patient often faints, recovers, and faints again, and is usually restless, tossing from side to side in bed, and expressing great anxiety about his condition. In syncope, there is usually preliminary nausea, ringing in the ears and dizziness, and when the actual attack ensues, the patient becomes completely unconscious. In fat embolism, the symptoms usually develop twenty-four to forty-eight hours after the injury, when there is sudden pallor, irregular heart action, difficult breathing, and perhaps convulsions. This occurs chiefly after fractures or operations on bone. Fat will be found in the urine. In hysteria, there are usually the characteristic stigmata of the disease, the temperature remains normal, and careful observation will usually detect a flaw in the symptoms complex.

PROGNOSIS OF SHOCK.

This depends on the degree of the injury, the severity of the symptoms, the general condition of the patient, and the presence or absence of complications like septic infection. Shock may prove instantly fatal, as in death from a blow over the solar pelxus, or the patient may live one or two days and finally die, or recovery may take place when hope has been practically abandoned. Shock, the result of profuse hemorrhage, is more dangerous than shock from other causes.

TREATMENT OF SHOCK.

While much difference exists among surgeons as to the treatment of shock when it develops, there is great unanimity of opinion as to the necessity of using certain measures to prevent its occurrence. Shock is rarely seen in a hospital where well conducted operations are skillfully performed on properly prepared patients. The call for curative treatment of shock is now principally seen in cases injured in railway accidents or other catastrophes.

PREVENTIVE TREATMENT.

1. Avoid *Fright*, by gaining the patient's confidence, inspiring him with hope, and sending him to the table in good mental condition. If the operation be one of election, the surgeon should be absolutely frank in discussing the dangers of the procedure at the time the patient is considering whether or not to have it done. If, however, it is decided to do the operation, the surgeon should no longer refer to the possibility of disaster or death, but should become optimistic and dwell on the relief and benefits to be expected. If, at the time of the operation, the patient is nervous, it is often wise to give a hypodermic of morphine. In the case of a child, when possible, it is well to fix the hour of the operation so that the anesthetic may be given while asleep.

Sometimes an adult is met with who is so panic-stricken at the thought of an operation that it may be necessary to adopt the following method suggested by Crile, which, of course, should only be carried out with the full consent of near relatives or friends. The surgeon tells the patient on his admission to the hospital that he does not know whether or not it will be necessary to operate on him, and that he will only undertake the case with the distinct agreement that he is to do whatever he thinks best. The consent of the patient having been obtained, he is subjected to considerable preliminary examination, and told that it is probable he can be cured by the inhalation treatment. An anesthetizer goes to his bed at a certain hour each day, places a mask over his face, and lets him inhale alcohol, disguised with some aromatic agent. At the same hour on the day set for the operation, the alcohol is given as usual, with the slow addition of an anesthetic, until unconsciousness is produced and the patient can be transported to the operating room. This expedient has, in Crile's opinion, enabled him to save several lives which would otherwise have been lost.

2. Avoid the *Loss of Blood* during the operation, by the use of Esmarch's bandages and constrictors in amputations, by angulation of the table in work on the head and neck, and by carefully and quickly catching and tying all bleeding vessels. Bloodgood says that a long, bloodless operation is less likely to produce shock than a short, bloody one.

3. Avoid the *Loss of Heat* by operating in a warm room, keeping exposed viscera and raw surfaces protected with hot moist towels, and seeing that the patient does not become wet with solutions. It is also wise not to have the patient in actual contact with the surface of a glass or iron table, but to interpose some non-conductor, if not actually to put him on a hot water pad.

4. Avoid the *Loss of Time*, not by breathless haste, which might lead to imperfect work, but by having a distinct plan of the operation in mind and executing its various steps speedily. Occasionally, in extremely difficult and tedious operations, requiring more than an hour for their execution, it is well, if circumstances permit, to do part of the work one day and complete it one or two days later. Victor Horsley advocates this being regularly done in cerebral surgery, trephining and exposing the dura one day, and subsequently dividing it and doing the work in the brain structure.

5. Avoid *Bruising and Tearing Tissue*, roughly handling or pulling on viscera. Dissection should not be made bluntly, and all manipulations should be gently carried out. The fact that the patient is under an anesthetic and his sensory centers unable

to appreciate pain, does not mean that his vaso-motor and cardiac centers are equally protected and he cannot develop shock.

6. Avoid the *Division of Large Nerves*, especially in weak patients, until these have been blocked by the intra-neural injection of cocaine. Crile says: "As no impulses of any kind can pass either upward or downward, there is no more shock in dividing tissues—even the nerve trunks themselves, thus blocked—than in dividing the sleeve of the patient's coat." In operations on the lower extremity and pelvis, this principle can be more extensively applied by injecting the cocaine into the spinal canal at or near the fourth lumbar vertebra.

CURATIVE TREATMENT.

When shock is actually in existence, treatment is of little avail, and in using remedies, the surgeon should be careful that, if he do no good, at least he do no harm. Senn says that it is as important to know what not to do as to know what to do, and Warren emphasizes the fact that it should be clearly remembered that the condition is one of exhaustion, and that rest is needed for repair. As the symptoms of shock are those of profound weekness and prostration, it was long a practice to give stimulants, such as alcohol, digitalis or strychnine. According to the modern pathology, which is undoubtedly correct, these remedies do harm. The centers are already partly or completely paralyzed from overstimulation, and the administration of strychnine according to Mummery, "is like beating a tired horse. It may call forth an effort if we beat hard enough, but it hastens the end." Or, to quote Crile—"It would be just as logical to treat strychnine poisoning with traumatic shock as to treat traumatic shock with strychnine."

The only logical remedy is one which will act, not on the centers but on the dilated vessels, restoring the peripheral resistance. Unfortunately, we have no satisfactory means to accomplish this end. The following is a brief dsecription of the present accepted mode of treatment.

1. Secure physiological rest by placing the patient in a quiet room, excluding all friends and relatives, and giving a moderate

dose of morphia. The surgeon and attendants should be calm and confident in their manner, and the patient should not be allowed to infer that his condition is unusual or alarming.

2. Apply external heat by placing the patient between warm blankets, putting hot water bags to the feet, thighs and body, and, in some cases, injecting hot fluids into the rectum.

3. Mechanically support the circulation by posture, by bandaging, or by the pneumatic suit. In mild cases of shock, all that may be necessary is to lower the head of the bed, thus gravitating the blood to the anemic brain. In graver cases, the limbs should be enveloped in elastic, non-absorbent cotton, and firmly bandaged from extremity to body. A compress may also be applied over the abdomen. Crile's pneumatic suit is an appliance by which the entire surface of the body is subjected to pressure by compressed air. Unfortunately, however, it is rarely at hand when needed.

4. Transfusion, with warm saline solution by rectum, beneath the skin, or into a vein. In cases of shock due to hemorrhage, this is the most logical and efficient method of treatment. In cases of shock from other causes, however, it is not so valuable. The average individual can only take up about two quarts of the solution. After this amount has been given, an interval must elapse, and then only two or three ounces given at a time. If this precaution is disregarded, fatal complications may ensue from edema of the pulmonary or abdominal regions.

5. The administration of adrenalin chloride, which is usually effected by combining it with the saline solution used in transfusion, one drachm of the 1-1000 commercial solution being added to one quart of normal salt solution and introduced slowly, but continuously, the rate regulated by the character of the symptoms or the record of a sphygomanometer.

QUESTION OF OPERATING DURING SHOCK.

In accident cases the surgeon is confronted with the question whether to operate at once or wait for reaction; whether he had better add the shock of an operation to the shock of the injury, with danger of death of the patient, or whether he had better wait, hoping for improvement, but possibly sacrificing the patient's only chance for life. There is no rule, although most authorities advise waiting, unless the mutilation causes great pain, or unless hemorrhage is actually in existence. On the other hand, Wainwright says: "To remove the nerve impulses after trauma, an immediate repair of injury is very important. Leaving a mangled, oozing limb, with crushed and exposed nerves, with the hope that it will give more favorable opportunity for intervention, will, in many cases, by allowing the cause continually to act, only drive the patient in a condition beyond all hope."

LECTURE XXIII.

SURGICAL FEVERS — MECHANISM REGULATING TEMPERATURE OF THE BODY — CAUSES OF ITS DISARRANGEMENT — CLASSIFICATION OF SURGICAL FEVER — ASEPTIC FEVER—AUTOTOXEMIA—SAPREMIA: DEFINITION — PATHOLOGY — CAUSES — SYMPTOMS — DIAGNOSIS—PROGNOSIS—TREATMENT.

The normal temperature of man is said to be about 98.4° F., and this is maintained in health with practically little variation, regardless of whether he is in the Tropics or in the Arctic regions, by an arrangement called thermotaxis. Briefly stated, heat is produced by combustion, and is dissipated by radiation and evaporation, and the two processes must be correlated in order that the mean temperature may be constant. If the production of heat should exceed its loss, the temperature would rise; and if the production of heat was less than the amount given off, it would fall. As a matter of fact, both of these processes are subject to constant variations. Thus, for instance, after taking food or after vigorous exercise, heat production is increased; while during abstinence from food and freedom from exertion, it is lessened. These changes are balanced, however, by a corresponding alteration of heat loss, effected by vaiations in the circulation and respiration, by the dilatation or contraction of the cutaneous vessels, and by the altered amount of moisture on the skin, varying from insensible perspiration to copious sweating. These changes are accomplished by the action of centers in the brain. In a word, man is an automatic, self-regulated stove, with a delicate and beautifully adjusted thermostat.

In disease this mechanism becomes disarranged, owing to the influence of new and unusual factors, and there is elevation of temperature, called fever. This is most frequently due to increased heat production, but, of course, may be due to diminished heat loss. In case of microbic infection, the presence of toxins in the blood acts by stimulating the thermogenic centers in the brain. In general, it may be stated that fever is caused by presence in the blood of a pyrogenous substance of an organic nature, due either to cell disintegration, to the absorption of products of putrefaction, or to the action of bacteria on the fluids and tissues of the body itself.

Surgical Fever.

The term surgical fever, strictly speaking, should include all types of fever occurring in a patient the victim of injury or operation, or suffering with a disease remediable by surgical measures. A study of the subject, however, from this broad standpoint is not practicable, and hence the term will be limited to fever occurring purely as the result of an injury or operation. Even with this interpretation, it is difficult to present the subject satisfactorily, as no two authors adopt the same classification, and also because many different and meaningless terms are employed in literature to designate the various types of the condition. The division that will be adopted here is based on the etiology as far as this is understood at this time, and is as follows:

1. Aseptic fever, due to the absorption into the system of the products of aseptic tissue necrosis. Under this head comes simple traumatic fever.
2. Septic intoxication, due to the absorption into the system of the products of putrefaction. Under this head come autotoxemia and wound sapremia.
3. Septic infection, due to the introduction into the system of living pathogenic organisms. Under this head come septicemia and pyemia.

I. Aseptic Fever.

Aseptic or simple traumatic fever is due to the absorption into the system of nucleins and albumoses, incident to aseptic tissue necrosis at the site of injury.

Pathology. It has long been known that the introduction into the circulation of certain harmless substances was capable of producing an elevation of temperature. The phenomenon is sometimes seen after intravenous infusion of normal salt solution, after transfusion with blood from a healthy animal, or after the injection of pancreatin, pepsin or trypsin. It is believed by Bergmann that the fever in the above instances is caused by destruction of red and white blood corpuscles and the liberation of fibrin ferment, and he therefore suggests that the condition be called fermentation fever, owing to it being due to the presence of fibrin ferment in the blood. In aseptic fever there is no infection of the wound, healing occurs promptly, and there is restoration of function more or less complete, according to the severity and character of the injury. There are practically no changes in the blood, although occasionally a trivial, non-progressive leucocytosis may be noted.

Causes. Aseptic fever is likely to follow an operation or injury if strong antiseptic solutions are used in the wound, causing superficial necrosis, with subsequent disintegration of cells. It is also noted where, owing to imperfect hemostasis or inadequate provision for drainage, a blood-clot forms in the wound, which breaking down and undergoing absorption, introduces pyrogenous substances into the circulation.

Symptoms. Fever makes its appearance within a few hours after the infliction of the wound, and the temperature rapidly reaches its height, varying from 100° to 104°F., though a temperature over 102° is very exceptional. It continues with little intermission, to drop suddenly to normal within two or three days. With the exception of the fever, there are practically no symptoms; the patient feels well, and cannot understand the solicitude of his nurse or attendant.

Diagnosis. This is based on the absence of the local signs of infection, on a history of the use of strong antiseptics in the wound, the probability of the retention of blood or secretions, the fact that the fever was not inaugurated by a chill, and the lack of coincident symptoms such as nausea, malaise or mental depression.

Prognosis. This is good, as patients invariably make a spontaneous recovery.

Treatment. The treatment is entirely prophylactic, and consists in avoiding the use of antiseptic solutions sufficiently strong to cause coagulation necrosis, and in being careful to arrest all oozing and bleeding before closing the wound, and if this is not possible, to provide for the escape of secretions by efficient drainage.

Should aseptic fever develop, no treatment is necessary, as it shortly runs its course, without serious detriment to the patient. The importance of its prophylaxis is chiefly on the surgeon's account. No matter how careful the operator has been in his technique, or how plain the symptoms may be in a given case, there is always a doubt in his mind as to the accuracy of his diagnosis, and he is never free from anxiety until the patient's temperature becomes normal.

II. SEPTIC INTOXICATION.

Septic intoxication is the constitutional effect produced by the absorption into the system of the products of putrefaction, and is, therefore, caused by saprophytic organisms. This type of fever may be subdivided into autotoxemia, caused by defective elimination of metabolic substances or decomposition of food in the intestinal tract; and into sapremia, due to the presence in a wound of dead tissue infected with saprophytic organisms, whose putrefaction results in the formation of a toxin. It will thus be seen that autotoxemia and sapremia are identical in nature, both being due to the introduction into the system of a chemical poison, the difference being that, in the first, the toxic material is formed in the tissues or a normal cavity of the body, while in the second, it is formed in an accidental or operative wound.

1. *Autotoxemia.*

Autotoxemia is due to the presence in the system of an excess of alkaloidal substance, caused by faulty metabolism, retrograde metamorphosis or fermentative changes.

Pathology. It is a well known physiological fact that some substances elaborated by cells are injurious to these same cells if the product of their activity accumulates upon them. A man only escapes intoxication from self-poisoning by the eliminative action of the skin, lungs, kidneys and intestinal tract. For instance, it is said that he secretes enough toxic matter in the bile in twenty-four hours to kill three men of the same weight as himself.

Metchnikoff, in his book on The Prolongation of Life (1908), attributes senile changes in man and animals principally to chronic autotoxemia, due to putrefaction in the intestinal canal. He shows by many illustrations that animals whose food remains for a long time in their intestines live but a short period, as compared with those whose excreta are ejected almost as rapidly as formed. He states that running birds, who have large intestines, containing an enormous number of bacteria, live only a few years, while flying birds, who have no colon or bladder and therefore a scanty intestinal flora, live for a much longer time. He cites the case of parrots, ravens, and even birds of prey who feed on putrid meat, who live to be from 80 to 100 years of age. Just as under normal conditions, chronic autotoxemia produces senility, so under abnormal conditions, acute autotoxemia may produce fever.

Causes. The causes of acute autotoxemia are the accumulation of excrementitious matter in the tissues, or the collection of putrescible material in the intestinal tract. A surgical patient often develops a form of blood poisoning in which the poison does not originate in the wound, and for which the surgeon is not responsible, except insofar as he has neglected to carry out certain measures in preparing the patient before the operation, or in treating him after an accidental injury, in order to make active the emunctories and rid the system of toxic products.

Symptoms. The patient, two or three days after the injury or operation, or even later during his convalescence, loses appetite, becomes restless and fretful, and has a headache, coated tongue and foul breath. The bowels are constipated, and the urine is concentrated. There is no chill, but the temperature rises until it reaches 100° or 102° F., and continues at this point, with practically no variation. The pulse and respiration are but little changed. These symptoms continue until by proper treatment, the accumulated effete matter in the system is eliminated, when they rapidly disappear.

Diagnosis. This is based on the presence of the symptoms described and on a history of improper preparation of the patient before the operation, or of inactivity of the emunctories afterwards. The condition must be carefully differentiated from infection, which can be done by an examination of the wound and failure to find the local signs of inflammation.

Prognosis. The symptoms usually yield readily to treatment. The condition, however, depresses the general vitality of the patient, retards convalescence, and predisposes to infection.

Treatment. The importance of preventing acute autotoxemia in surgical cases is becoming more generally recognized. Patients before being operated on should be properly prepared. After an operation, the diet should be carefully regulated and all the emunctories kept active, so as to prevent the accumulation of toxic products in the system. If symptoms of autotoxemia develop, the liver, bowels, kidneys and skin should be made active by the administration of mercurial purgatives, by drinking large quantities of light water, and by the use of baths, alcohol rubs, and general massage. In those cases characterized by impending kidney breakdown, spartein sulphate given in one grain doses hypodermically is excellent in its results.

2. *Sapremia.*

Sapremia is due to the absorption into the system of chemical poisons produced by putrefaction of necrosed tissue in a wound.

Pathology. For sapremia to occur, there must be a wound containing dead tissue infected with saprophytic organisms. Park likens the condition to the action of a hypothetical septic suppository. No germs are found in the blood or internal organs, because saprophytic bacteria cannot live in normally vitalized tissue. It cannot develop from a small point of infection but must come from an accumulation of dead material in a space of considerable size, as it has been estimated that it is necessary for from one to two ounces of fluid, saturated with the products of germ growth, to be absorbed into the system in order to produce serious symptoms. As an example of sapremia, is usually cited the putrefaction fever following the breaking down of a blood-clot in the puerperal uterus. As long as this clot does not putrefy, it is disintegrated and discharged with the lochia, with the production only of aseptic traumatic fever. When, however, saprophytic organisms enter either during or after labor, putrefactive processes are set up, with the production of toxins and ptomaines. Sapremia is not limited to absorption from the uterine cavity, but may occur from the putrefaction of a blood-clot or any devitalized mass of tissue, wherever located. It was almost invariably seen in a grave form during convalescence after the old operation of hysterectomy, where the pedicle was brought into the wound and strangulated with the ligature or serre-noeud. It frequently follows compound fractures or similar injuries, where there is devitalization of tissue, or the occurrence of concealed hemorrhage, followed by infection.

Causes. Sapremia is not due to infection of the blood or tissues of the body with pathogenic organisms, but is caused by the absorption of chemical poisons elaborated in a wound by the action of saprophytic or putrefactive bacteria on non-vitalized or dead tissue. For the condition to develop, three factors must coexist—first, the presence of dead tissue; second, its infection with putrefactive bacteria; third, a sufficient length of time for decomposition to ensue and for the toxins to be absorbed. In treating the condition it must be remembered that the symptoms are due to the absorption of toxic matter which, while being produced in a wound, amounts practically to being formed outside of the body.

Symptoms. Sapremia of grave degree is usually initiated about twenty-four hours after the accident or operation by slight rigors or an actual chill, which is followed by fever, the temperature quickly reaching, in some cases, 104° or 105° F. The fever is continuous, with slight remissions. The pulse is at first rapid and strong, but if a large dose of poison is absorbed, it soon becomes weak and irregular. The face is flushed and the tongue dry. There is complete loss of appetite, sometimes vomiting. The patient may be constipated, or may have diarrhea. The urine is concentrated, of high color, loaded with urates, and on standing becomes muddy. Nervous symptoms are usually marked; there is depression or irritability, restlessness or anxiety, and in severe cases, coma may ensue, generally terminating in death. An examination of the wound will show it to contain a blood-clot or mass of devitalized tissue undergoing putrefaction, as demonstrated by its disintegration, the presence of gas, and characteristic odor.

Diagnosis. This is based on the symptoms, and made certain by the discovery of dead or putrefying tissue in the wound.

Prognosis. This depends upon the amount of poison absorbed before a diagnosis is made, and the possibility of removing the putrefying mass after its discovery, and thus arresting further introduction of toxic products. Sometimes the initial dose of poison is fatal. Again, the symptoms may rapidly improve with the removal of a decomposing blood-clot or detached fragment of placenta, and the disinfection and drainage of the cavity.

Treatment. Prophylaxis consists in preventing accumulation in a wound of material which can putrefy, or in protecting devitalized structures which cannot at the time be removed, from becoming infected with saprophytic organisms. Thus, for instance, after compound fracture, opening and turning out blood-clots, and removing fragments of bone or devitalized soft tissue; or in cases of senile gangrene, preventing decomposition by the disinfection and protection of the dead part.

The curative treatment of sapremia consists in opening the wound, removing dead tissue, and thoroughly disinfecting the cavity and providing for its subsequent drainage. The constitutional symptoms must be combatted by eliminative and supportive measures. The bowels and kidneys should be made active, tonics such as quinine and iron administered, nutrition in the shape of concentrated and easily digested food, and stimulants such as strychnine and whiskey prescribed in full doses.

LECTURE XXIV.

SURGICAL FEVERS (CONTINUED)—SEPTICEMIA AND PYEMIA: DEFINITION — PATHOLOGY — CAUSES — SYMPTOMS — DIAGNOSIS—PROGNOSIS — TREATMENT.

III. SEPTIC INFECTION.

A sharp distinction must be made between septic intoxication, which is due to the absorption into the system of the products of putrefaction, and septic infection, which is due to the introduction into the system of micro-organisms, which retain their capacity for reproduction in the blood. In one case the poison is a chemical agent which can, in a large measure, be controlled; in the other it is a vital agent, which, once in operation, has passed beyond the reach of local treatment. In septic intoxication, the poison is absorbed from a source practically outside of the body; while in septic infection, the poison is elaborated in the blood and tissues of the patient himself. For septic intoxication to develop, there must be a cavity of considerable size to contain putrefying tissue; while septic infection often starts from some trivial wound, such as a needle prick or slight abrasion received during an operation on a septic patient, or in a post-mortem upon a body dead of some virulent disease. In septic intoxication, the symptoms often manifest themselves suddenly, with maximum intensity, owing to the rapid absorption of a large dose of chemical poison; while in septic infection, the symptoms are more gradual in onset, as it usually takes some days for the germs to effect localization and produce toxins.

1. *Septicemia.*

Septicemia is a form of fever due to the introduction into the system of living pathogenic micro-organisms, which multiply in the blood and tissue, producing progressive sepsis.

Pathology. Many different varieties of bacteria are capable of causing septicemia. The size and location of the wound through which they enter does not influence the virulency of the disease. The degree of sepsis resulting is dependent on the number and character of the invading organisms, and on the resisting power of the patient. After the microbes gain an introduction into the body, they enter the circulation, either directly through a vessel wall, or more indirectly through the lymphatic system. They become widely disseminated, undergo rapid proliferation, and produce toxins directly in the blood and tissues of the victim. There is a short period of incubation after infection, before development of symptoms, because some time must elapse before a sufficient amount of poison is produced to have a constitutional effect. The condition, however, is progressive, and the symptoms grow steadily worse; and unless there is early intervention on the part of the surgeon, or great resistance on the part of the patient, death is almost inevitable.

Causes. At one time it was believed that septicemia was due to a specific germ, the microsporon septicus. It was next thought that it was caused only by pyogenic organisms, such as the streptococcus, staphylococcus, gonococcus, pneumococcus and colon bacillus. The reason WHY inoculation with pus microbes will cause local suppuration in one case, progressive septicemia, in a second, and pyemia in a third, does not permit of satisfactory explanation. It is now known that, while a large majority of cases of septicemia are due to pyogenic organisms, other bacteria also have the power of producing sepsis. Septicemia is sometimes seen following wounds that do not suppurate, and, in fact, some of the gravest types, such as puerperal septicemia, or blood poisoning following a dissecting wound, are due to germs which have no pyogenic properties.

Symptoms. The symptoms of septicemia usually develop from one to three days after infection takes place. They are gradual in onset, but tend to become progressively worse. There is often a more or less distinct chill, followed by a gradual rise of fever, the temperature varying between 103° and 106° F. The pulse is at first strong, but becomes rapid, small and intermittent as the disease progresses. A low temperature, with a weak, compressible pulse indicates a graver degree of sepsis than a high temperature, with a good pulse. The face presents a characteristic appearance. The skin is yellow, the cheeks flushed, and the eyes sunken and surrounded by dark circles. The patient is apathetic and listless; he complains of no pain; states that he is feeling well; and shows no anxiety about his condition. There is complete loss of appetite, some nausea, and perhaps vomiting. The urine is scanty, high colored, and loaded with urates. An examination of the wound will show the local signs of infection.

As the disease becomes more severe, delirium ensues, muscular tremor develops, the tongue becomes dry and cracked, the pulse progressively weaker, and the patient exhibits the picture of the so-called typhoid state. The blood always shows lecocytosis, which is progressive in character. The number of leucocytes often reaches 40,000. There is an increase in the proportion of polynuclear cells, and the iodine reaction is positive.

Diagnosis. The diagnosis is based upon the occurrence of fever and the other symptoms described the second or third day after the injury or operation, and the evidence of infection in the wound.

The condition must be distinguished from aseptic fever, autotoxemia, sapremia, typhoid fever, and acute suppurative osteomyelitis. Aseptic fever occurs within a few hours after the infliction of the wound, and never develops later than twenty-four hours. The fever at once reaches its maximum, and the general condition of the patient remains good. Acute autotoxemia occurs in patients whose emunctories are inactive. There is no sign of infection in the wound, and the symptoms are promptly relieved by eliminative treatment. Sapremia is marked by the sudden onset of the symptoms, and the presence of putrefactive changes in the wound. Typhoid fever has its prodromal stage, usually no history of trauma, and can be diagnosticated positively by the diazo and Widal tests. Suppurative osteomyelitis can be recognized by the presence of tender points at the juncture of the shaft and extremity of the long bones.

Prognosis. This is always grave, and depends upon the character of the infection, the resisting power of the patient, the severity of the symptoms, and the accessibility of the primary point of infection to surgical treatment.

Infection with streptococci is more fatal than with staphylococci. A mild case of septicemia in an individual of poor vitality or the victim of some organic disease, is more dangerous than a graver degree of septicemia in a healthy, vigorous individual. The outlook is bad when the temperature is subnormal, the pulse weak, the tongue dry and brown, vomiting persistent, and the patient delirious or comatose. The prognosis is more favorable when the infection takes place at a point accessible to local disinfection, than when it occurs at a location difficult to reach.

Treatment. Prophylaxis consists in the aseptic and antiseptic treatment of wounds to prevent infection in operative cases, and to effect sterilization in accidental injuries. Senn states that, "any method or methods of treatment which can be relied upon in the prevention of suppuration, will be found equally efficient in preventing septic infection."

When septicemia develops, the wound should be opened, irrigated and disinfected, thoroughly drained, and protected with a wet antiseptic dressing. The patient's bowels should be moved with a small dose of calomel, and afterwards controlled, if necessary, by bismuth and salol. His strength and resisting power should be sustained by stimulants and food. Strychnine should be given hypodermically in large doses, and alcohol in sufficient quantity to produce decided effect. Concentrated, nutritious, but easily digested food should be administered by mouth in small quantities at frequent intervals. If the condition of the stomach is bad resort must be had to rectal feeding, and a nutrient enema of peptonoids, whiskey and saline solution given every six hours. Fever must be combatted by cool baths and alcohol rubs, and nervousness and insomnia controlled by the administration of small doses of morphine. Formalin solution in a strength of 1-800 has been recommended, by hypodermoclysis, but it is doubtful if it is any better than simple salt solution, which acts by diluting the toxins in the blood, and favoring their elimination through the kidneys. Intravenous injection of colloidal silver is reported by numerous authorities to be of decided benefit in some cases. The use of Marmorek's anti-streptococcic serum will often be followed by a cure in a pure streptococci infection, but the remedy is useless and often dangerous when the condition is due to other organisms, and hence it should only be employed after a bacteriological examination of the wound secretion or blood of the patient.

2. *Pyemia.*

Pyemia is a form of fever due to the entrance into the circulation of pus or pyogenic micro-organisms, and their distribution through the circulation as emboli, resulting in the formation of metastatic abscesses.

Pathology. Every case of pyemia is secondary to a local focus of suppuration. The steps of the process are as follows. There is infection of tissue, and suppurative inflammation takes place. With the extension of the process and invasion of adjacent structures, a vein is finally reached. The pus organisms attack its coats, producing phlebitis. The tunica intima becomes roughened, and as a consequence, thrombosis or coagulation of blood occurs. The intravenous clot, being septic and friable, undergoes disintegration, and emboli are thrown into the circulation. These lodge at various parts of the body, producing infarction or ischemia of a wedge shaped portion of tissue. The infarct becoming infected from the septic plug which produced it, softens, liquefies, and is converted into pus, constituting a metastatic abscess.

A thrombus is an intra-vascular or intra-cardiac clotting of blood, occurring during life. The thrombosis of pyemia is primarily a phlebitis. The endothelial lining of the vessel becomes rough, leucocytes accumulate upon it, and coagulation of blood results. According to their location with reference to the vessels, thrombi are described as arterial, venous, capillary, or cardiac; according to this composition, as white, red, or mixed. Clinically, thrombi are classed as simple or aseptic, and infectious or septic. From a surgical point of view, especially in relation to pyemia, all thrombi should be regarded as infectious. The causative factor is a pyogenic microbe; the primary lesion, a phlebitis; the terminal process, thrombosis and embolism.

Septic thrombi tend invariably to disintegration or puriform softening, and small fragments containing pyogenic organisms become detached, and enter the general circulation. Such emboli during their transportation through the circulation, become arrested and establish independent centers of suppuration. An embolus is a detached thrombus, or some foreign material which is carried into the blood current, and thence transported to its place of impaction. The process of transportation is called embolism.

Emboli lodge in small arteries and capillaries, causing obstruction, and the tissues thus affected by the interruption of circulation constitute what is known as an infarct. An aseptic embolus produces purely mechanical disturbance at the seat of lodgement, and its effect is as though the vessel had been tied. Infected emboli, such as result in pyemia, are made up of fragments of infected thrombi, and when implanted in a tissue remote from the primary focus, set up independent centers of infection by the same micro-organism that was present in the original focus. Infarcts are usually wedge shaped, the apex of the wedge corresponding to the location of the embolus, and its base made up of the tissue within the area of the ultimate branches of the obliterated vessel. Since the infected thrombus is always located primarily within a vein, in close proximity to the seat of original infection, the detached emboli are conveyed to the right side of the heart, and are apt to become impacted in the branches of the pulmonary artery. The lung, therefore, is the most common seat of metastatic abscesses. Emboli however may escape the filtering action of the lungs and enter the arterial system. When this occurs, they ultimately lodge in the terminal vessels of the kidneys, spleen, liver, brain, skin, etc., producing metastatic abscesses in these organs.

Causes. Pyemia is invariably produced by pyogenic bacteria. In the majority of cases, infection is with the streptococcus or staphylococcus, although sometimes the gonococcus, penumococcus, typhoid or colon bacillus are responsible. In the preantiseptic days pyemia was extremely common, but with present methods, it is now rarely seen in surgical practice. It occasionally occurs when wounds have been infected through faulty technique, or at the time of an accident. It is also sometimes seen in obstetrical practice, as a complication of puerperal infection. It is not uncommon as a result of suppurative osteomyelitis, appendicitis, cholecystitis, or suppuration in other deeply located structures, in which early operation is not practiced.

Symptoms. Pyemia never occurs before suppuration has taken place, and the symptoms usually do not develop until the seventh to the eleventh day after the primary infection. The premonitory symptoms consist in an altered appearance of the wound, the pus, instead of being yellow and creamy, becoming thin and streaked with blood. The granulations become pale and flabby, and frequently thrombosis may be detected in an adjacent view. The patient loses appetite, has a general feeling of malaise, and develops a slight fever.

The first actual manifestation of pyemia is usually a chill, which is followed by a high fever, lasting several hours and terminating in a copious sweat. The temperature frequently goes to 105° or 106° F., but in a few hours falls almost to normal. The peculiar characteristic of pyemia is the irregular recurrence of the chill. In acute cases sometimes there are two or three a a day, increasing in frequency and intensity as the disease grows worse, while in chronic cases sometimes there are only one or two a week coming at longer intervals as the disease gets better. The pulse at first is in proportion to the fever, but later continues rapid and feeble the entire time. The mental faculties are not affected. There is no apathy or indifference, and the patient fully recognizes his danger. In the later stages of the disease, prostration may cause coma before death. There is usually loss of appetite, foul tongue, and bad breath. The urine is scanty and high colored. The skin has a marked yellow discoloration resembling jaundice. This is of hematogenous origin, and there is no bile in the urine unless an abscess develops in the gall tract or liver.

In a short while metastatic abscesses develop in various parts of the body, the symptoms depending on the organ involved. If in the lungs, there will be an irritating cough, difficult breathing, and characteristic physical signs. If in the liver, there will be tenderness, enlargement of the organ, and perhaps local peritonitis. If in the spleen, there will be sudden pain, followed by swelling. If in the kidney, there will be blood and pus in the urine. If in a joint, there will be the evidences of suppurative arthritis.

Diagnosis. The diagnosis is based on the presence of a suppurating wound, on the occurrence of a chill after the expiration of the period of incubation, which recurs at irregular intervals, attended by high fever and followed by exhaustive sweats.

Pyemia must be differentiated from malaria, typhoid fever, and various suppurative processes which give rise to localized collections of pus. It is often mistaken and treated for malaria, but a differential diagnosis can easily be made by a blood examination, pyemia showing an enormous leucocytosis, and malaria exhibiting the pathognomonic plasmodium. From typhoid fever it can be differentiated clinically by a careful valuation of the symptoms, and if this is not sufficient, by recourse to laboratory methods.

Prognosis. This is based largely on the acuteness or the chronicity of the disease. Acute pyemia usually terminates fatally within five or six days. The chronic type of the disease, under proper treatment, often recovers, although relapses are frequent and the time of convalescence is long. In many cases when recovery occurs, the patient is left with a crippled heart, on account of endocarditis.

Treatment. Pyemia, strictly speaking, is not a disease, but a sequel of suppuration. Its prophylactic treatment, therefore, consists in treating wounds so as to prevent the formation of pus. Prevent suppuration after a surgical operation, or combat it if it develops in an accidental wound, and the possibility of pyemia is absolutely eliminated.

The curative treatment of pyemia is the treatment previously given for septicemia, plus the active pursuit of metastatic abscesses, which, when accessible, should be promptly incised, evacuated, and drained.

LECTURE XXV.

ERYSIPELAS — DEFINITION — CAUSE — DESCRIPTION OF SPECFIC GERM — PATHOLOGY — GENERAL AND LOCAL SYMPTOMS — CLINICAL TYPES — DIAGNOSIS — PROGNOSIS — TREATMENT— CURATIVE POWER OF ERYSIPELAS.

Erysipelas, or St. Anthony's Fire, is an acute non-suppurative inflammation of the superficial lymphatics of the skin or mucous membrane, caused by a specific germ and characterized by redness and a continued type of fever. The disease was formerly a frequent complication after accidental operative wounds, and at one time prevailed in a malignant form throughout both Europe and America. Descriptions of an epidemic of erysipelas that occurred in the United States in 1842 are to be found in all lengthy treatises on the disease. In this epidemic deep structures were involved, extensive disintegrations of tissue took place, and the discharges were so acrid that they acted on steel like the strongest acid. Instruments used in the wounds and left uncleaned would in a few hours be so corroded as to be worthless. The mortality of the disease during this epidemic was great. Fortunately since the use of asepsis and antisepsis erysipelas has almost disappeared and the few cases that still occasionally develop are of a mild type and rarely result in death.

Cause. It has long been known that erysipelas was contagious, and as soon as the germ theory of disease was established investigators began to attempt to isolate the essential microbe. The early efforts resulted in failures and it was not until 1883 that Fehleisen succeeded in reproducing the disease not only in animals but in man, by the injection of a pure culture of what is now known as the streptococcus of erysipelas. These cocci are from three to four microns in diameter. They grow in serpentine chains, multiply by direct division and are readily stained with ordinary aniline dyes. Owing to the close resemblance observed between the streptococcus of erysipelas and the streptococcus of suppuration it was at once claimed that they were identical and this view is still held by many good authorities, who believe that they are the same germs showing different activities, and producing different results because they are placed under different external conditions. A careful and impartial consideration of the arguments on both sides has led me to the conviction that the streptococcus of erysipelas is distinct from the germ of suppuration, and that the question of their identity would never have arisen except for their unfortunate resemblance in shape and grouping. The streptococcus of erysipelas never causes suppuration and if pus develops during the progress of an attack of erysipelas, it is always due to secondary infection with one of the numerous species of pyogenic bacteria.

Pathology. The unbroken skin is a complete barrier against the entrance of the germ of erysipelas. For infection to occur there must be an infection atrium. There is no such thing as idiopathic erysipelas, and when a case develops where there is no obvious point of entrance it should not be looked upon as an exception, but merely as an instance in which the defect in the skin or mucous membrane was so small as to be incapable of being demonstrated at the time of examination. After gaining entrance the cocci locate principally in the superficial lymphatics of the skin. They multiply so rapidly that the vessels are soon filled and it is difficult to find a lymph corpuscle. The current in the vessels is arrested and a progressive lymphangitis is instituted. The infection spreads by continuity of tissue, the germs being most numerous on the edge of the advancing inflammation. Observation shows that the germs are short-lived and do not survive for more than three days at one point. Tissue infected soon becomes sterile, the wave of infection sweeping over it, exhausting its nutritive resources and seeking pastures new. In other words, erysipelas is a tramp and has to "move on" to gain subsistence.

Symptoms. The period of incubation of erysipelas varies from fifteen to sixty-one hours. This has been definitely determined by many cases in which the disease has been artificially caused for therapeutic purposes. The disease can be produced by dipping a needle in a pure culture of the organisms and then pricking with this needle the skin. Such punctures leave no visible lesion after a few hours and illustrate the fact that infection atria can not be demonstrated in all cases. Before the development of well marked symptoms there may be headache and malaise, but usually the first evidence of the disease is a sharp chill, or what is its equivalent in a child, a convulsion. This is followed by a rapid rise in temperature to 104°, and even more. The fever is a continuous type and, unless there are complications, shows little or no remission. There is headache, thirst, loss of appetite, nausea and perhaps vomiting. The pulse-rate is increased. Its volume is at first full and strong, but later it may become weak from toxemia. In severe cases there may be delirium or even coma. The local symptoms of erysipelas develop simultaneously with the constitutional, and consist in a crimson discoloration at the point of infection attended by a sense of tightness, itching and a burning pain. The skin around the infection atrium is firmer to the touch than normal and the characteristic dusky redness extends rapidly to involve the adjacent surface. The discoloration is more or less uniform, and light pressure will show that the disease is superficial and does not affect deep structures. The edges of the inflammatory area are sharply marked and are more or less zigzag in outline, one writer stating that they resemble the edges of burnt paper, another that they have fan-like prolongations. The amount of swelling varies with the anatomy of the part involved. In loose tissue, such as the face or neck, swelling is considerable. In compact tissue such as the finger tips swelling is inconspicuous. As the inflammation increases in intensity numerous vesicles form; many of these coalesce and large bullæ filled with serum result. With convalescence these vesicles and bullæ dry and form yellowish or brownish scabs, so that during resolution there is considerable desquamation. In true erysipelas there is no suppuration. If pus forms it is a complication due to secondary infection with pyogenic germs.

The local changes above described do not remain focused at one point but tend to spread in various directions. When an extremity is involved the direction of spread is usually towards the trunk and when on the face usually towards the scalp. The disease does not localize itself to one point for more than three or four days and then moves on to adjacent structures. The part first involved may become inflamed a second time, however, and this tendency to recur is one of the characteristics of the disease. Volkmann says, "It is like a fire over which we have no control; it burns on wherever it finds material, and it suddenly breaks out afresh in a spot where it was supposed to be extinguished."

Erysipelas is a self-limited disease and usually exhausts itself in from one to two weeks. If it can be confined to a limited area it soon ceases.

Varieties. The clinical forms of erysipelas are all due to the same germ and attended by the same pathological changes, but they vary with the part affected and the complications that ensue.

1. *Phlegmonous Erysipelas* is a type of erysipelas complicated by suppuration. As it has been clearly proved that the germ of erysipelas does not cause suppuration the presence of pus can only be explained by coincident infection of the tissue with pyogenic cocci. When this double infection occurs the clinical picture is a composite one of the two septic processes, the symptoms of suppuration overshadowing those of erysipelas. The temperature shows greater fluctuation, the pulse becomes weaker and more rapid, and the swelling is no longer limited to transudation into the skin, but affects the deeper tissues as well. Pus undermines the skin, dissects up fascia and separates muscles. The external appearance of the part often gives little evidence of the damage inflicted to the deeper structures and prompt incision is necessary to save life or limb.

2. *Erysipelas Gangrenosum* is a type of erysipelas attended by gangrene of the part involved. It is caused by germs of great virulence acting on tissue of low resistance. The bacteria multiply with rapidity and block lymphatic circulation. Toxins are produced in large quantities and gangrene of the skin follows.

This death may involve isolated patches of cutaneous surface or may result in total death of a large area. This type gives a grave prognosis. I recently saw, as consultant, a case where this type of the disease attacked the scrotum from infection with dirty finger nails. The inflammation was unattended by suppuration but caused the death of the skin of the entire scrotum, the inner sides of the thigh and the lower portion of the abdomen. The man died of acute septicemia.

3. *Erysipelas Metastaticum* is a type of erysipelas in which the specific inflammation develops at another part of the body without involvement of the intervening skin or the implantation of germs through a second infection atrium. This may be explained in two ways: either the infectious agent is carried by the lymphatic stream or else is conveyed by means of an embolus through the blood current. Examples of the above are noted when in the course of erysipelas on one limb the disease appears on another extremity, or when during the course of facial erysipelas there is suddenly the development of fatal meningitis due to infection of the membranes with the specific streptococcus.

4. *Erysipelas Neonatorum* is a type of erysipelas attacking the umbilicus of a new-born child. This type was exceedingly common in the lying-in hospitals of the pre-antiseptic era, and proved almost invariably fatal. Fortunately now it is very rare. It is mentioned to impress the necessity of cleanliness in the dressing of even the most trivial wounds. When it developed it rapidly spread over the entire abdomen and death resulted from depression of vital powers at a time when the hold on life was feeble.

5. *Erysipelas of Mucous Membranes.* This condition is sometimes overlooked because the scarlet discoloration is not so obvious owing to the lack of contrast to the normal color of the part. When nasal mucous membrane is invaded there is swelling of the lachrymal duct; when the pharyngeal mucous membrane is involved there is usually enlargement of the sub-maxillary and cervical glands. When the mouth is involved the tongue may be much swollen and discolored, causing the so-called "black tongue." The disease may extend to the larynx causing

fatal edema, or to the bronchi and lungs causing pneumonitis. Erysipelas may also attack the vagina, urethra, bladder or rectum.

6. *Facial Erysipelas* usually begins at the ala of the nose, a point the common seat of minute lesions and one especially liable to become infected from unconscious manipulations with the fingers. The inflammation usually extends to the cheek and orbit of the affected side, then crosses the bridge of the nose to the opposite side, causing an area of erythema of butterfly shape. It then invoves the forehead, the scalp, and terminates usually in from seven to ten days at the back of the neck. It rarely if ever involves the chin and anterior part of the face. There is usually considerable swelling especially of the loose tissue around the orbit. The eyes are often closed for several days. The principal danger is the possibility of extension of the disease to the meninges of the brain.

Diagnosis. The diagnosis of erysipelas is easy in a well marked, uncomplicated case. The existence of an infection atrium, the chill and high fever, the characteristic crimson blush with its sharply marked zigzag outlines, give unmistakable evidence of the nature of the disease. It can be distinguished from simple erythema by the existence in the latter of islets of healthy skin in the inflamed area; from deep lymphangitis, by the location of the induration; from phlebitis, by the discoloration being in the form of red streaks which follow the anatomical course of the vein in the latter and the vessel being demonstrable as a hard tender cord; from phlegmonous inflammation, by the lack in the latter of a well defined limit to the redness and by its beginning in deep structures and becoming superficial in its later stages.

Prognosis. The prognosis of erysipelas in uncomplicated cases is good, but it is grave when it is associated with suppuration or gangrene, and attending sepsis, or when complicated by meningitis or the involvement of other inaccessible structures. In this as in other diseases, the age, general health and surroundings of the patient largely influence the prognosis.

Treatment. The preventive treatment of erysipelas consists in the immediate disinfection and proper dressing of accidental wounds, in the application of efficient aseptic and antiseptic measures during the infliction of operative or intentional wounds, and in the isolation and quarantine of cases of erysipelas as soon as a diagnosis is made to prevent the spread of infection to other individuals. The *constitutional treatment* of erysipelas consists in the use of remedies and measures to sustain strength and regulate the functions of the body. Usually the first prescription is for a saline or mercurial purgative to empty the bowels and thus remove a source of irritation which is largely responsible for the anorexia, nausea and vomiting. Sleeplessness and delirium, if present, should be combated by small doses of opium, bromide or chloral. Concentrated, nutritious, but easily digested food should be ordered in small quantities at frequent intervals. Abundance of drinking water should be insisted upon to aid the emunctories. Alcoholic stimulants should be unhesitatingly prescribed if indicated. Fever should be controlled by cold sponging. Tincture of chloride of iron and sulphate of quinine are time honored remedies and may be given for their supposed alterative and tonic effect. The anti-streptococcic serum has been used and good results are reported, although its use is illogical if it is believed that the germ of the disease is distinct from the germ of suppuration. *The local treatment* of erysipelas consists in the application to the part affected of remedies so numerous that only a few of them can be mentioned. The fact of their great number is proof conclusive that there is no one specific. Erysipelas is an acute self-limited disease and tends to spontaneous recovery. The last local application made is the one accredited with the cure that has come through natural agencies. It is eminently proper for the surgeon to apply local treatment but he should be certain that, if he does no good, at least he will do no harm. Irritants and caustics such as tincture of iodine and nitrate of silver should not be used as they cause solution of continuity of the skin and predispose to the danger of secondary infection. Scarification around the inflamed area with the hope of arresting the spreading lymphangitis has proved ineffectual and should be avoided for the same reason. The best course to pursue is to disinfect the part affected as if it were to be the seat of a surgical operation and then apply one of the following preparations:

1. Coat the part with a 5 per cent ointment of ichthyol in lanoline.

2. Apply a mixture of 5 per cent resorcin, 5 per cent ichthyol, 40 per cent mercurial ointment and 50 per cent lanoline.

3. Use Crede's Soluble Silver Ointment (15 per cent).

4. Paint the part with pure carbolic acid and as soon as it becomes bleached neutralize the drug by the application of alcohol.

Curative Properties of Erysipelas. It has been observed that an attack of erysipelas occurring as a complication in certain diseases often produced decided beneficial and sometimes curative effect on the primary trouble. There are numerous reports of cases in which keloids, lupus, carcinoma and sarcoma have been apparently cured by accidental attacks of erysipelas. At once the possibility of using the disease as a therapeutic remedy was appreciated and many patients suffering with inoperable troubles were intentionally inoculated with the essential germ. The deaths which followed, however, brought the practice into disrepute. Coley of New York has attempted to secure the possible curative effect of erysipelas without the danger incident to the disease by using the toxins in place of the germs. He discovered that the toxins of the streptococcus of erysipelas were made more active by combination with the toxins of the bacillus prodigiosus, and the mixture of the two can now be bought. The injection of Coley's Mixed Toxins in the dose advised causes constitutional reaction in the form of a chill, fever and sweat. The local effect is not so obvious. Coley does not claim that the treatment does much good in carcinoma but says that it has decided curative effects in many cases of sarcoma. He reports a number of cases of permanent recovery following its use. There is no question of Coley's honesty or diagnostic ability but it must in fairness be stated that no one else has been able to get the same results. Senn has tried it on fifty cases with absolutely negative results in every instance. Keen and White of Philadelphia give equally discouraging reports. It has been used in St. Luke's Hospital of this city on twelve cases and the sarcomatous growths have not been improved while the general strength of the patient has been much impaired. The last word has not yet been said on the subject and the future alone can decide whether or not the remedy has a place among our therapeutic resources.

LECTURE XXVI.

TETANUS AND HYDROPHOBIA—SYNONYMS, DEFINITION, CAUSE, VARIETIES, PATHOLOGY, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT.

Tetanus or lockjaw is an infectious disease in which the specific germ through its toxins acts on the central nervous system, producing rigidity and spasm of definite groups of muscles. The germ of tetanus was not discovered until 1884, but long before this time, from clinical observations, it was known that the disease was infectious. An instance was on record in Brazil, in which several slaves ate the flesh of an animal dead from tetanus and three of them developed the disease. Another case is reported in which a horse died of tetanus, and afterwards three puppies which lived in the same stable suffered the same fate. Still another illustration was the case of a woman who fell while walking through a barnyard and wounded her elbow. She developed lockjaw, and upon investigation, it was found that a horse infected with the disease had previously been in the enclosure.

Cause. The essential cause of the disease has been definitely proven to be a rod-shaped germ commonly called the "drumstick" bacillus, owing to the development of a spore at its end which gives it a fancied resemblance to the stick of a bass drum. The germ is anaërobic, multiplies by spore formation, is extremely resistant to heat and can be cultivated on a sterilized solid blood serum, if oxygen is excluded. The germ is widely distributed in nature, being commonly found in stable manure, street sweepings, garden soil, and in building débris, such as plaster and mortar. Within the past few years it has also been discovered in gunpowder, blank cartridges and other explosives. The organism can not live when exposed to the atmosphere and its natural habitat is the deeper layers of the soil. A certain degree of warmth is favorable to its growth and multiplication; hence it is more often found in southern than in northern climates. The bacillus of tetanus when inoculated into an animal does not enter the blood, but remains localized and produces its systemic effect by the elaboration of toxins, which are absorbed and act upon the central nervous system. These toxins have been carefully studied and have been classified as of at least two varieties, tetanospasmin and tetanolysin. Different symptoms have been ascribed to each, but for practical purposes they may be considered as one. The bacillus of tetanus cannot enter the tissues of the body through an unbroken skin or intact mucous membrane. In every case of tetanus there must be an infection atrium, although it may be so trivial that at the time of development of the disease it may not be demonstrable.

Punctured, lacerated and gunshot wounds are favorable avenues for entrance, owing to the fact that oxygen does not find easy access to them and germs implanted in their depths find suitable conditions for growth. Wounds of the hands and feet are more likely to be followed by tetanus than wounds of other parts of the body, simply because they are not protected by hair or clothing and are more likely to be contaminated with materials infected with the organism. The period of incubation, or length of time after infection before the development of symptoms, is extremely variable, sometimes being only twenty-four hours, and again, two or three weeks. This depends on the virulence and number of bacilli introduced, and also on the resistance offered by the system to their action. Lockjaw occurs in men oftener than in women, owing to their greater liability to injury, and is also usually seen, for the same reason, between the tenth and thirtieth year, although no age is entirely exempt. It is most frequently seen in jockeys, stable boys, gardeners and street cleaners, who, by their occupation, are more exposed to infection, and has recently been noted as common in boys the victims of wounds inflicted by the toy pistol on the Fourth of July or Christmas.

The toxins act solely upon the nervous system, first the spinal cord and later the brain. Moreover the toxins are carried from the point of formation in the wounded and infected tissue, to the cord, not by the circulation but solely through the motor nerves. This knowledge has an important bearing upon the treatment of the disease.

Symptoms. Tetanus begins insidiously. The patient feels irritable and indisposed; he has sensations of chilliness and a feeling of soreness in the muscles, especially of the neck. The first definite symptom of the dread disease is the accidental discovery of inability to open the mouth. This is due to spasm of the muscles of mastication and is called trismus. The patient next finds difficulty in swallowing, as the muscles of deglutition become involved. Next there is rigidity and spasm of the muscles of the neck and spine, causing retraction of the head and an arched condition of the back, termed opisthotonos. In bad cases the patient will be bent like a bow and rest on his occiput and heels, his buttocks being elevated several inches above the bed. Finally the muscles of respiration are affected, causing irregular and difficult breathing. The face of the patient has a peculiar, expressionless or mask-like appearance, due to the rigidity of the facial muscles. Frequently there is a ghastly grin, caused by the contraction of the risorius muscles. The contractions above described are clonic and are aggravated into paroxysmal seizures by the slightest irritation, such as unexpected noises, drafts of air, or efforts to change the patient's position in bed. The temperature rapidly rises and sometimes goes as high as 108° to 110° F. Respiration is impeded and dyspnea and cyanosis are present. The sensorium remains clear and the special senses are intact. Pain is excruciating. Death, when it occurs, results from exhaustion, due to fever, inability to take food and embarrassment of respiration. If recovery ensues, there is gradual improvement of the symptoms in the reverse order of their development.

CLINICAL FORMS OF TETANUS.

Acute Tetanus. The stage of incubation is comparatively short. Rigidity of the jaws is rapidly followed by involvement of the other muscular groups. The temperature is high, pulse rapid, and death results, as a rule, in from one to five days.

Chronic Tetanus. The period of incubation is longer, the symptoms develop more gradually and are never as well marked as in the foregoing. There is trismus, some opisthotonos, but the muscles of respiration are not involved. The disease may last from six to ten weeks.

Trismus. The only symptom of this form is stiffness of the masseter muscles and inability to open the mouth. It rarely proves fatal, except when the disease attacks the very young.

Tetanus Neonatorum. This form is seen in infants during the first week of their life and almost invariably proves fatal. The infection takes place through the umbilicus.

DIAGNOSIS.

A positive diagnosis is made on the history of a wound inflicted under conditions liable to be accompanied by infection with the bacillus of tetanus on the rigidity of the masseter muscles followed by the involvement of the muscles of the neck, back and chest in regular and orderly succession, on the occurrence of convulsive seizures from trivial irritation, and on the presence of high fever, attended by rapid prostration.

The differential diagnosis between tetanus and strychnine poison is based on the fact that in the latter there is no history of an injury and the symptoms develop suddenly, with maximum intensity. Hysteria is differentiated by the absence of fever, trivial alteration in the pulse rate, and the convulsive movements not being limited to any definite group of muscles. Hydrophobia as will be seen later gives the history of a bite by a rabid animal, a longer period of incubation, and the spasms are primary in the muscles of deglutition.

PROGNOSIS.

The prognosis depends upon the type of the disease and upon the resisting power of the patient. Most cases of acute tetanus die, while many of the chronic cases recover. Taking all cases, the mortality is about 75 per cent.

TREATMENT.

Prophylactic. As lockjaw, when it occurs, usually follows insignificant injuries, it is the duty of the surgeon to treat the smallest lesion with greatest care; especially should this be the case when the wound is a punctured one, contaminated with stable manure, street sweepings, garden soil, building débris, or the powder and wadding of explosives, especially the toy pistol. The wound should be opened to the bottom, foreign particles of every description removed, the surface thoroughly disinfected and the cavity loosely packed with gauze. If the wound be suspected of harboring tetanus bacilli and especially if inflicted by a toy pistol, it is advisable, in addition to give prophylactic doses of antitetanic serum.

Curative. In acute cases practically nothing can be done except to palliate the symptoms. In chronic cases, which may be recognized by their longer period of incubation, and more slowly symptoms developing with less intensity, there is greater prospect of a successful result from the surgeon's efforts. It has been stated by a writer of experience that if a patient can be kept alive for five days he will probably recover. The first thing to do is to open up and thoroughly disinfect the wound through which the infection entered, and afterwards to treat it with moist antiseptic dressings. Then there should at once be given large doses of antitetanic serum. At this point it is important to comprehend some recently acquired knowledge relative to the technique of administration of antitoxin. It has been stated that the toxins of tetanus are carried to the spinal cord and medulla solely by the motor nerves. The antitoxin however is carried chiefly through the circulation, though it neutralizes the toxin whenever brought into contact. It is therefore obvious that when the antitoxin is used for curative purposes it should be injected first into the immediate area of the wound, then into the proximal portion of the motor nerves of the part, and finally into the circulation by way of a vein. Roger's treatment is based on this principle and is applied as follows: Ten to 20 cc. are injected subcutaneously about the wound, the same quantity is injected into a superficial vein and 5 to 20 minims are injected into the nerves of the brachial plexus if the wound is of the upper extremity or into the sciatic, crural and obturator nerves if of the lower limb, and 10 to 20 cc. into the cauda equina. In some cases injections are also made into the spinal cord. If antitoxin is not available the next best treatment is the hypodermic administration of aqueous solution of carbolic acid—three grains of the drug the first day, and the amount increased to six or eight grains the succeeding days. To relieve pain and relax the muscular spasm give chloral hydrate and bromide of potash, by rectum, morphine by hypodermic injection, and, if necessary, chloroform by inhalation.

At this point it should be mentioned that subdural injections of magnesium sulphate in solution have been used as a palliative remedy. This substance has distinct anti-spasmodic and anesthetic action when directly applied to nervous tissue.

The regular administration of a satisfactory quantity of food and stimulant is most important, and owing to the locked condition of the jaws is often exceedingly difficult. Usually the patient has to be anesthetized and liquids introduced into the stomach through a large catheter inserted through the nostril or through an opening made by the extraction of one of the teeth. Rectal feeding may also be practiced. It is essential to administer saline enemata. Patients suffering with tetanus should be kept in a quiet, dark room, and all sources of excitement carefully avoided. Under the belief that tetanus was a form of neuritis, nerve section and nerve stretching have been practiced, but without result. Some surgeons have advised amputation, but the operation is only indicated to relieve local conditions and has no influence on the disease itself.

HYDROPHOBIA.

Hydrophobia, rabies, or lyssa, is an acute infectious disease, the germ of which has not been identified. It is usually contracted from the bite of a rabid dog or cat in whose saliva the virus exists. The disease never originates spontaneously, but always has origin from a previous case. The term hydrophobia means literally a dread of water. It should not be applied to the disease as it occurs in dogs, because an animal suffering from it will make an effort to drink at every opportunity.

Rabies in Dogs. Two distinct forms occur—the furious form and the paralytic form or dumb rabies. The cause and pathology are the same, and one may give rise to the other. There is a marked difference, however, in the symptoms.

Symptoms. In the furious form three stages may usually be observed—the melancholic, the furious and the paralytic. In the melancholic stage there is restlessness, irritability and loss of appetite. A desire for unnatural food is developed, the animal eating such things as straw, paper, feathers or bits of wood. There is also marked sexual excitement. The dog becomes shy, avoids notice and seeks dark places, probably on account of photophobia. Breathing and swallowing are difficult and the animal appears to have a foreign body in its throat. The bark becomes hoarse and a peculiar howl may be heard. The saliva becomes viscid and general weakness is apparent.

The furious stage comes on in two or three days. The dog usually leaves home and may travel great distances, running aimlessly, and, without provocation, attacking any animal it may meet. If confined, it makes desperate efforts to break its chain, biting viciously any object within reach. At this stage the dog is probably delirious, visions of imaginary objects causing it to snap in the air.

Exhaustion now appears and the paralytic stage sets in. The dog curls up in a fence corner or some secluded spot, ready, however, to attack any one who may arouse it. The expression at this stage is horrible—the eyes are sunken, the pupils dilated, the tongue red and protruding from an open mouth which drips saliva. Paralysis develops, affecting first the hind legs, then the lower jaw, and finally the entire body. Convulsions may occur and death from general exhaustion results in from five to eight days after the first onset.

Dumb Rabies. In this form excitement and fury are absent and paralysis sets in early, beginning in the lower jaw, which drops, allowing the tongue to hang out, which becomes dark and congested. Hence the name, "black tongue," often used by those who do not understand this form. There is, of course, no danger of being bitten, but a wound on the hand may become inoculated with saliva when administering medicine, or attempting to remove a bone supposed to be in the dog's throat.

Diagnosis. Usually the peculiar symptoms leave no room for doubt as to the nature of the disease. In doubtful cases the dog or cat should not be killed, but securely confined and watched. If death does not occur within ten days the fear of rabies was unfounded. If the dog be killed or die with suspicious or inconclusive history and symptoms, the stomach contents should be examined and the head packed in ice and shipped to a Pasteur Institute, where, by microscopic examination of the brain and ganglia, or by inoculation of rabbits, the diagnosis can be cleared up.

Hydrophobia in Man. There is no question that rabies affects human beings. It is a rare disease, however, as, according to the United States census, only thirty people died from it in this country last year. The number would be larger but for the almost routine use of prophylactic inoculation in suspicious cases.

Cause. The disease is almost certainly due to an organism as yet unidentified. It never occurs except by transmission from one animal to another. The virus is in the nervous system, saliva, urine and milk of a rabid animal. It is essential that the poison be inoculated through an abrasion of the skin or mucous membrane for the disease to follow.

Symptoms. The incubation period in man is from two weeks to one year, varying according to the location, number and severity of the wounds. The average period is about two months. The prodromal symptoms consist in depression of spirits, loss of appetite and inability to sleep. The wound, although perfectly healed, may become painful. In a day or two there is difficulty in swallowing, and the voice has a sobbing tone, owing to interference with the respiratory movements. An attempt to drink water brings on gasping and a paroxysmal closure of the throat. Thick, viscid saliva accumulates in the mouth, causing irritation, which makes the patient clutch wildly at his throat in an endeavor to relieve himself. Often there is a short, loud cough something like the barking of a dog. There is mental depression, then confusion, excitement and a sense of impending danger. Delirium or coma may supervene. There is fever, with a temperature gradually increasing until finally it reaches 105° F. The pulse is rapid and feeble and there is often involuntary urinary and fecal discharges. The patient finally dies from failure of respiration.

Diagnosis. This is based upon the history of having been bitten and the peculiar symptoms above outlined. Hydrophobia differs from tetanus in its longer period of incubation and in the fact that there is no rigidity of the jaws, but the spasm of the muscles is confined to those of deglutition. Hydrophobia can be distinguished from lyssophobia, which is a nervous manifestation of an intense dread of the disease occurring sometimes in those bitten, by the absence of fever and other signs of genuine infectious processes.

Prognosis. The disease once developed, the prognosis is hopeless. Fortunately, only 20 per cent of the people bitten by rabid animals develop the disease even if not treated. If all cases bitten were at once sent to a Pasteur Institute, only one out of every three or four hundred would have it. Severe and mutilating bites are most dangerous, especially if on the bare skin. Bites on the face, scalp and neck have a short period of incubation, and hence require prompt treatment.

Treatment. The virus should be removed from the wound by sucking or cupping. It should then be cauterized with pure nitric acid or a red-hot iron, and protected with a moist antiseptic dressing. If there is no question of the fact that the animal inflicting the wound had rabies, the patient should be sent at once to the nearest Pasteur Institute where a treatment consisting in the daily hypodermic injection of an emulsion made of the spinal cords of rabbits dead of rabies is practiced. By this method immunization is established in about thirty-five days. Delay in sending the patient for treatment increases the danger as the disease may develop before immunization can be obtained.

Fortunately we have a properly equipped Pasteur Institute in Richmond. After hydrophobia develops in a patient, treatment is hopeless and all that can be done is to relieve, in a degree, the acuteness of the symptoms. Chloroform should be freely employed to relax the muscles and control paroxysms. Restraint is necessary to prevent the patient doing himself harm. The doctor and nurse should remember that his saliva and urine contain the virus and should carefully avoid becoming infected through open sores. When the patient is dead, the body should be thoroughly disinfected before burial.

LECTURE XXVII.

ANTHRAX—GLANDERS—ACTINOMYCOSIS—SYNONYMS, DEFINITION, CAUSE, PATHOLOGY, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT.

ANTHRAX.

Anthrax, malignant pustule, or wool-sorters' disease, is an acute infectious disease, due to an essential germ, characterized by inflammation at the point of inoculation, and often by general infection and death. The disease is of peculiar interest because it was the first to be absolutely proven to be due to a germ. Anthrax among animals has been recognized for centuries. At one time it was thought to be a species of malaria, but in 1849, Polender, with the crude microscope then in use, discovered the presence of innumerable fine, rodlike bodies in the blood of animals suffering with the disease. The bacillus which was finally proven to be the cause of the disease is the largest of the known pathogenic microbes, and ever since its discovery has been a favorite subject of study by the bacteriologist.

Causes. The bacillus of anthrax is a rod-shaped germ from 5 to 10 micromillimeters in length and from 1 to 1.25 micromillimeters in breadth. It multiplies by spore formation in the test tube and by direct division in the bodies of living animals. It is extremely resistant to heat, grows in all of the common culture media, and can be easily stained by the aniline dyes. The germ is found in nature on grass and vegetation in swamps and along the banks of streams. It is especially prevalent in Russia and Siberia, and is also common in Hungary and in certain parts of France and Germany. Herbivorous animals become infected with it while grazing, the seat of inoculation being usually the lips, mouths or intestinal tract. Anthrax in man is always acquired from the infected animal. Any part or tissue of an animal dead of the disease is capable of communicating it. The bacillus is capable of preserving its virulency for many years. Anthrax is usually transmitted to man by means of horse hair, wool or hides, and is most commonly seen among butchers, tanners and wool-sorters.

The infectious agent may gain entrance through, (1) the gastro-intestinal canal; (2) the respiratory passage; or, (3) the skin. The first two avenues result in internal anthrax, which properly comes under general medicine. Infection through the skin results in external anthrax, which is a surgical condition.

Pathology. The bacilli of anthrax are found in great numbers in the blood and multiply so rapidly that they block the capillaries and lymphatics. This produces acute ischemia, with local necrosis. When general infection takes place, the capillaries in every part of the body are loaded with the organisms.

Symptoms of External Anthrax. The manifestation of the disease depends upon the anatomical structure of the part involved. If it is dense and vascular, a circumscribed carbuncular inflammation develops—anthrax carbuncle. If it is loose connective tissue with comparatively poor blood supply, a diffuse inflammatory infiltration develops—anthrax edema.

Anthrax Carbuncle. Within a few hours to three or four days after infection, a slight burning and itching develops at the point of inoculation, which is usually on the hand or face. A papule forms which soon becomes converted into a vesicle. This bursts and exposes necrotic tissue beneath it. Inflammatory infiltration rapidly extends, the slough grows larger, phlebitis and lymphangitis develop, and septic symptoms result. The condition is somewhat similar to an ordinary carbuncle, but is more rapid and acute, and differs in the fact that there is but one focus of infection, whereas, in an ordinary carbuncle due to pyogenic infection, there are a number of foci, which develop simultaneously, and present separate openings on the skin.

Anthrax Edema. Anthrax edema follows infection of loose connective tissue where the blood supply is poor, such as the eyelid, neck or forearm. There is rapid swelling in all directions, attended by livid discoloration of the skin. Blebs or blisters may form on the surface, filled with bloody serum. Occasionally local gangrene results. General infection is shown by a chill, fever, delirium and rapid prostration.

Diagnosis. The diagnosis is based on the fact that the patient has handled hides or sorted wool, upon the typical appearance of the anthracic carbuncle with its tough slough firmly adherent to adjacent tissue, and of the anthrax edema with its rapid and unlimited swelling and discoloration and disintegration of the skin. If there is any doubt, the diagnosis can be settled by staining and examining the fluid or tissue for the characteristic germs, or by inoculating a rabbit or mouse with a drop of blood or serum taken from the center of the inflammatory area, which, if the disease be anthrax, will cause its death in the course of two days.

Prognosis. If the disease is promptly diagnosed and radically treated, the prognosis is good. If it is allowed to run its course and energetic measures are not employed until systemic infection takes place, the prognosis is bad. The prognosis of anthrax carbuncle is better than anthrax edema.

Treatment. The local treatment is the most important. If the lesion be small, frequently it may be cured by saturating the infected tissue by the parenchymatous injection of a 5 or 10 per cent solution of carbolic acid. The surface should be thoroughly disinfected and the needle of the hypodermic syringe introduced through healthy skin one-fourth of an inch outside the border of infiltration. Usually from four to twelve punctures are made. The injection should be repeated every six hours until the disease is under control, or until the amount of carbolic acid introduced has reached the limit of safety. If this method fails, the surgeon should resort to excision and cauterization. The diseased area is removed as if it were a malignant growth, and the raw surface resulting thoroughly burned with the actual cautery. It is said that shepherds in districts where anthrax is prevalent destroy the vesicle with a red-hot needle as soon as it develops, and it is seldom that infection does not yield to this treatment.

The constitutional remedies to be employed consist in the usual means to combat prostration and collapse from septic infection, such as stimulants, tonics and supporting measures.

GLANDERS.

Glanders, farcy or equinia, is an infectious disease caused by a specific germ, the bacillus mallei, characterized by ulcerative lesions at the seat of inoculation, and later by constitutional infection. The disease always originates with a horse, and occurs in man by contagion.

Cause. The bacillus of glanders is a small, rod-shaped germ, somewhat shorter and broader than the bacillus of tuberculosis. It has rounded ends, usually occurs in pairs, and is very resistant to heat and other germicides. It is supposed to multiply by spore formation, can be grown on most of the usual culture media, and is stained by the ordinary aniline dyes.

Glanders in the Horse. Glanders and farcy in the horse are different manifestations of the same disease. Each may be acute or chronic, the difference being merely one of degree. In glanders, there is fever, rapid pulse, accelerated breathing, and other symptoms of sepsis. Ulceration occurs in the mucous membrane of the nose, larynx, trachea and bronchi. There is a copious discharge of mucus, which causes the horse to cough and sneeze. The lymph nodes in the submaxillary and cervical regions enlarge, suppurate, and frequently burst. In farcy a number of distinct swellings or nodules appear beneath the skin all over the body, called "farcy buds." They vary in size from a pea to a hickory-nut. They suppurate, discharge and leave ragged ulcers which may become confluent and form large ulcerative areas.

Glanders in Man. Glanders in man occurs practically only in those who have to do with horses. The disease may be contracted by inhaling the virus sprayed into the air by the coughing of diseased animals, but is usually contracted by infection of an abrasion upon the skin from contact with material containing the specific micro-organism.

Pathology. The bacillus of glanders produces chronic inflammation which results in the formation of embryonal cells in quantities sufficient to produce a granuloma. The microscopic picture is almost identical with that of tuberculosis, except that there are no giant cells. The granuloma soon becomes secondarily infected with pyogenic organisms, softens, breaks down, discharges, and produces an ulcer.

Symptoms. The disease may be either acute or chronic. In acute cases, after an incubation of from three to six days, there is a chill, followed by fever, and at the point of inoculation, there is the development of a nodule, which undergoes liquefaction, rupture and discharge of a reddish fluid having a vile odor. Disintegration of the tissue rapidly takes place and increases in extent and depth until tendons, bones or joints are exposed. There is profound prostration, and death usually results within two weeks.

In chronic cases there is a period of incubation of one or two weeks, and the disease runs a course of months or years. The lesions are usually numerous and resemble tertiary syphilis. Often infiltration, ulceration and healing go on simultaneously.

Diagnosis. The diagnosis is based upon the occupation of the patient, the clinical characteristics of the local lesions, and finally upon the detection of the specific microbes by microscopic examination of the granulation tissue or of the discharges.

Diagnosis by inoculation consists in injection of the suspected product into the peritoneal cavity of male guinea pigs. If the disease is glanders, within three or four days the scrotum becomes red and glazed and suppurates, and the animal dies in from twelve to fifteen days.

Prognosis. All cases of acute glanders die. Fifty per cent of the chronic cases get well. The outcome is more favorable when the initial lesion remains localized and is accessible to surgical treatment, than when the lesions are disseminated and located in regions difficult to reach.

Treatment. The prophylactic treatment consists in preventing contagion by killing horses infected with the disease, and disinfecting the stable which they have occupied. If accidental inoculation be known or suspected, the site should be immediately thoroughly cauterized, and every abscess as discovered should be opened and disinfected by the application of nitric acid or the actual cautery. If multiple abscesses form, they should be opened, curetted and drained. Golds reports two cases of glanders in man cured by mercurial inunction. The internal use of iodine, creosote and arsenic has also been recommended. The general measures advised to combat prostration from sepsis should also be employed.

ACTINOMYCOSIS.

Actinomycosis is a disease due to infection with the actinomyces, characterized by chronic inflammation and the formation of a granuloma at the site of inoculation, which later becomes secondarily infected, suppurates and breaks down. Actinomycosis as a disease of cattle has long been recognized. It usually affects the jaw, causing enlargement of the head, commonly spoken of by stock breeders as "big-head," "big-jaw" or "lumpy jaw." The etiology and pathology of the disease were not understood until Bollinger, in 1876, described the fungus which was later proven to be its essential cause.

Cause. The actinomyces, or ray fungus, is not strictly speaking a bacteria, as it does not belong to the group of schizomycetes, but is a fission fungus, or hyphomycetes. It is not microscopic in size, but is large enough to be seen by the naked eye. The organism is found as a small yellow body in the pus from actinomycotic abscesses. When examined by the microscope, it is found to consist of threads which radiate from a common center, some of them having clubbed extremities. These threads are similar to the ordinary mycelium, and their arrangement gives the characteristic ray-like appearance.

Clinical experience proves that infection in animals and in man can take place with fragments of actinomyces and that the results are the same as when the whole fungus is inoculated into the tissue. The ray fungus grows both in the presence and absence of oxygen, stains readily by Gram's method, and can be cultivated on gelatin and blood serum. It multiplies by spore formation, thrives best at the body temperature, has low vitality, and is readily killed by disinfectants. Actinomycosis most frequently occurs in cattle, less often in horses and hogs. The infection is more apt to occur in cattle in damp and marshy regions, particularly land recently reclaimed from the sea. The frequency with which the disease is located in the tongue, cheeks and jaw, suggests infection by food, and cereals, especially barley, have been thought to convey the disease. It is a fact that actinomyces will grow when artificially implanted on grain, though the organism has never been found in nature under normal conditions. Healthy cattle stabled with infected ones seldom contract the disease, and infection has never been traced from cattle to man.

Pathology. When the actinomyces finds lodgment in the living body, it produces chronic inflammation which results in the form ation of a granuloma. The actinomyces is not a pyogenic organism and cannot produce suppuration. The granuloma, however, invariably after a longer or shorter time becomes secondarily infected with one of the pus germs, suppurates, breaks down and forms an abscess. The most striking characteristic of actinomycotic infection is the slow and steady involvement of adjacent tissue, the advance not being by continuity, but by continuity of tissue—in other words, starting in soft parts, it will attack adjacent bone, or beginning in the lung, instead of spreading through pulmonary tissue, it will advance to the pleura, and from it invade the rib and perforate the chest wall.

Symptoms. Actinomycosis in man has never been directly traced to infection from animals, although it is possible that eating raw or improperly cooked meat containing the organism might cause infection of the alimentary tract. Actinomycosis in man usually originates, as it does in animals, by infection of the jaws from masticating infected cereals. In reading the record of the cases reported, one is struck by the fact that most of the individuals state that they made a practice of chewing grain, and in several instances an infected ear of barley has been found embedded in the gums or tonsils. When infection takes place by the mouth, the patient gives a history of toothache, with swelling of the angle of the jaw and difficulty in opening the mouth and of swallowing. There is an external tumor which becomes red, softens, opens and discharges pus containing characteristic yellow granules. If the disease is allowed to continue untreated, the teeth drop out, and muscle and adjacent soft tissue are destroyed. Pus may burrow deep in the neck and point at considerable distance from the seat of original infection. Infection of the lungs may take place by inhalation of the intestinal tract by ingestion, and of the skin by contact with an abrasion. The constitutional symptoms are not marked, and there is little fever or impairment of weight and strength until chronic suppuration produces the "hectic state" similar to that seen in tuberculosis.

Diagnosis. Actinomycosis at first produces an enlargement which resembles a tumor more than an inflammatory swelling—in fact, the condition is often mistaken for sarcoma. The true nature of the disease can easily be determined after suppuration takes place by the presence of the small yellow masses resembling grains of iodoform which are found in the pus. Microscopic examination will show them to present the typical structure of the ray fungus.

Prognosis. The prognosis of actinomycosis is about the same as of tuberculosis. It is good when the disease is recognized early and when it is located so as to be accessible to radical treatment. It is bad when internal organs are involved either through primary infection or by metastasis.

Treatment. The surgical treatment of actinomycosis before suppuration has occurred consists in the removal of the entire mass of affected tissue. If the disease has become so disseminated that this is impracticable, then the infected area should be exposed by free incisions of the skin, the granulation tissue thoroughly curetted out with a sharp spoon, the bleeding surface disinfected and cauterized, and the resulting wound lightly packed with iodoform gauze. It should be kept open and carefully examined at each dressing. Should there be local recurrence, the operation must be repeated. Internal medication has little or no effect, although advanced cases have been reported to have been cured by the administration of large doses of iodide of potash.

LECTURE XXVIII.

SURGICAL TUBERCULOSIS — HISTORY OF TUBERCULOSIS — FREQUENCY AND IMPORTANCE OF DISEASE — EXPERIMENTAL STUDY — PATHOLOGY OF THE TUBERCLE — ARREST AND EXTENSION OF THE PROCESS.

Tuberculosis is a chronic infectious disease caused by a specific micro-organism, the bacillus of tuberculosis, and characterized by the formation of nodules or tubercles. In times past the disease was not of especial interest to surgeons, but it is now one of the most important and interesting subjects in the field of surgical pathology.

History. Laennec, in 1826, first recognized the inoculability of tuberculosis. Vellemin, in 1865, was the first to demonstrate the fact experimentally by transmitting the disease from man to animals. He infected rabbits with cheesy tissue from a tuberculous lung and demonstrated miliary tuberculosis at autopsy. He stated that pulmonary phthisis was a specific infection due to an infectious agent. Cohnheim showed that there was a period of incubation after infection before the development of the disease, and added much of interest to the study of tuberculosis by originating the experiment of inoculating the anterior chamber of the eye of an animal and watching the development of the disease through the transparent cornea. Toussiant showed that tuberculosis material could be transmitted from man to man and from animal to animal, reproducing the disease in each instance, while the material itself lost none of its virulency. Klebs, in 1877, was the first to successfully cultivate the microbe of tuberculosis. He also proved that the same organism was found in scrofulous glands, in lupus of the skin and in white swelling of the joints, as in tuberculosis of the lungs. It remained for Robert Koch, however, in 1882, to sum up the work of previous years in one masterly communication which forever set aside all skepticism. He showed conclusively that the bacillus of tuberculosis could be found in every tuberculous lesion; that it could be isolated and cultivated in suitable media, and finally he produced tuberculosis, *de novo*, in a healthy animal by inoculation with a pure culture of the organism. Up to the time of the publication of Koch's paper, the profession generally did not recognize the existence of tuberculosis except when the disease attacked the lungs. Tuberculosis of the glands, skin, bones, joints and other tissues of the body was classed under the general term scrofula or struma. They were considered to be local manifestations of an "hereditary blight," or "general dyscrasia," or "scrofulous diathesis." Under this vague nomenclature, the treatment for the local, and, therefore, curable, tuberculous processes was inefficient. It is now recognized that tuberculosis is tuberculosis, whether of the bone, brain or belly, glands, joints or lungs. The term scrofula has become obsolete, and by radical surgical intervention, the mortality from the disease has been rapidly reduced.

Frequency and Importance. Wherever man is found, tuberculosis is present as an everthreatening foe. There is scarcely a tissue immune to infection, and its ravages are seen in the hectic flush of the "lunger" or in the shape of disfiguring scars of the neck, distorted spines and crippled limbs. It is said that tuberculosis is responsible for 50 per cent of all human ailments, and to be the cause of the death of one out of every seven people who die. The word "consumption" ordinarily suggests an incurable condition which proceeds slowly to a fatal termination, and the public has greater dread of it than perhaps any other malady except cancer. Yet the majority of cases of tuberculosis can be cured if an early diagnosis is made by an intelligent application of rational measures.

Inoculation Tuberculosis. Vellemin, Cohnheim, Schuller, Koch and others have proved, step by step, that tuberculous material, whether phthisical sputum, an emulsion from tuberculous nodes, or urine containing the bacillus, can be introduced into the tissues of a lower animal and produce the disease. Fortunately, for science, most of the lower animals, such as the guinea pig, rabbit and mouse, readily contract the disease, hence the same difficulty has not been met in experimental inoculation as that which for a long time frustrated the effort to establish the germ of syphilis. While man has not been intentionally used for the purpose of experiment, still numerous cases are on record in which he has been accidentally inoculated, giving the opportunity to watch the development of the disease. Laennec nicked himself with a saw in the midst of an autopsy upon a tuberculous subject and had the doubtful pleasure of witnessing the development of tuberculosis in his own skin. He subsequently died of phthisis. Senn mentions the case of a girl, a rag sorter, who developed a small sore at the point of inoculation on her thumb, and afterward developed lymphatic infection of the forearm, with the formation of nodules and ulcers which presented unmistakable signs of their tuberculous nature. Another author reports the case of a servant girl who fell and broke the cuspidor of a phthisical patient, which she was carrying, cut her hands on the broken pieces, and in three weeks showed the development of tubercles. Another interesting case is that of a Jewish rabbi who, although phthisical, performed the rite of circumcision after the ceremonial order of the old Jewish ritual. The orthodox operation consists in stopping the bleeding by spitting styptic wine from the mouth on the amputated prepuce. Twelve children were said to have been thus inoculated by the rabbi on this most vulnerable and tender part and several died from the disease—a fate no less tragic than that which befell others who lost their organs.

Pathology. Tuberculosis, wherever found, is identified by the presence of the tubercle. Hence the tubercle is the foundation of the pathology of the disease. It has been said that the tubercle is to tuberculosis what the chancre is to syphilis—the specific lesion. It is more than this, however, as it is an expression of the effort of nature to control the disease by eliminating or rendering inert the noxious irritant that has been introduced into the body. The presence of the bacillus of tuberculosis in the tissue is an essential condition for the formation of a tubercle. The germ is small, its length being about one-half the diameter of a red blood corpuscle. It is rod shaped, straight or slightly curved, having rounded ends, and is usually found in clusters, although it may be found singly when there are few in the specimen. It multiplies usually by fission, although under some conditions it undergoes spore formation. It is very resistant to heat and other germicides, is difficult to cultivate and hard to stain. It will grow on sterilized blood serum and can be colored with alkaline aniline dyes. When stained, it cannot be bleached by either sulphuric or nitric acid. This makes the bacillus easy to identify. When introduced into the body through an infection atrium, the organism multiplies and produces its characteristic toxins. The tissues rebel as they do against the invasion of any irritant, and there follows the phenomena described as chronic inflammation.

Definition of a Tubercle. A tubercle is a nodule formed by an aggregation of cells which have been produced by chronic inflammation, the result of the infection of the tissue with the bacillus of tuberculosis. Upon microscopic examination it is found to be made up of leucocytes, epithelioid cells and giant cells, supported and held in position by a reticulum of connective tissue. Frequently, if treated by the proper staining method, the tubercle bacillus can be identified. We will take up the histological elements individually and then describe them collectively.

1. *The Leucocyte* is merely a white blood cell which has origin from the general circulation. In every case of inflammation there is more or less increase in the number of leucocytes in the part. The degree of leucocytosis depends upon the acuteness or chronicity of the infection. As tuberculosis is a typical low-grade inflammation, the number of white blood cells in the part is not great, and the leucocyte constitutes comparatively but a small part of the bulk of the tubercle.

2. *The Epithelioid Cell* is an embryonal or granulation tissue cell, the result of the division of the formative cells of the part. In chronic inflammation the irritation does not kill, but stimulates the formative cells, and as a result there is proliferation. The epithelioid cell is named from its resemblance to squamous

epithelial cells. It is two or three times as large as the leucocyte, granular in appearance, and constitutes a large portion of the bulk of the tubercle.

3. *The Giant Cell* is pathologically the most interesting of the three, and there is some question as to its origin. It is about one hundred times larger than the white blood cell, is finely granular and contains a number of nuclei arranged about the periphery of the cell. It is generally believed that the giant cell is an overgrown epithelioid cell, its enormous size being due to its failure to undergo division. Well may its sister, the ordinary epithelioid cell, knowing their common parentage, exclaim, "On what meat has this our Cæsar fed, that he has grown so great?"

4. *The Reticulum* is a fine mesh-work supporting the cells and binding them together. Most authors assume that it is the old connective tissue of the part, pushed asunder by the advance of the new cells.

Arrangement of the Above Elements. If a tubercle be carefully examined under the microscope, it will be found that the cells are arranged in three layers: First, the external or peripheral layer made up of small round cells, the leucocytes, which have come from the blood; second, the middle layer, made up of epithelioid cells, which compose the greater part of the tubercle. These cells are two or three times the size of the leucocytes and have resulted from division of the formative cells of the part. Third, the central layer of two or more giant cells, which are glutinous epithelioid cells, which have devoted nutrition not to propagation, but to corpulency. Ramifying between the cells is seen the delicate reticulum, and scattered among and in the cells, especially near the center, may be detected the tubercle bacilli. There are no blood vessels.

Development of the Tubercle. The primary tubercle is microscopic in size, but the continuous action of the irritant causes it to enlarge until it becomes macroscopic, perhaps as large as a millet seed. Other tubercles develop near it and coalesce with it until finally the entire tissue is involved and becomes a solid tuberculous mass, the conglomerate tubercle.

CHANGES IN THE TUBERCLE.

Coagulation necrosis, or the early death of the component cells of the tubercle, distinguishes it from all other granulomata. The causes of this are the specific action of the bacillus and its toxins and the absence of any direct blood supply, which is a peculiar feature of the tubercle. In other words, coagulation necrosis equals local toxemia plus ischemia. It begins in the center of the tubercle, as this is the point first subjected to the poison of the toxins and longest deprived of nutrition from the blood.

Caseation is the conversion of the tissue into a yellow, cheesy, unctuous mass. For a time, cell outlines and nuclei can be distinguished, but they soon become indistinct and disappear, and the whole mass becomes homogeneous, refuses to take stains, and the identity of its component parts is lost.

Liquefaction of the tissue follows and a circumscribed collection of fluid resembling pus occurs in the tissue. This is called a tuberculous or cold abscess. The term is unfortunate, as the fluid is not pus, but merely the liquefied product of retrograde tissue metamorphosis. The use of the terms, tubercular "pus," and tubercular "abscess," as applied to a condition separate and distinct from suppuration, is to be regretted, but there is no escape, as long as custom has thoroughly established them in literature. Senn states: "I believe that it can now be considered a settled fact that the bacillus of tuberculosis is not a pyogenic microbe. * * * The so-called tuberculous or cold abscess contains the fluid which resembles pus, but which shows none of of its histologic elements."

Infectiousness of Tuberculous Pus. When the tuberculous area has finally become converted into a full-fledged tuberculous abscess, it is difficult, and many say, impossible, to discover bacilli in the pus. This is due to the fact that its nutrition has been exhausted and the germs have died from starvation and intoxication from their own excretions. Yet it is true that while no germs can be found, the fluid is still highly infectious and capable of producing tuberculosis if injected into a guinea pig.

It is believed this is due to the presence of spores. The granulations lining the walls of the abscess and the tissue adjacent to it can usually be demonstrated to contain the active organisms.

Secondary Infection. Often, after a longer or shorter time, the caseous or liquefied focus becomes secondarily infected with pyogenic microbes. When this takes place there is a conversion of the caseous product into the true pus of an ordinary abscess. Sometimes there is a further complication, the addition of saprophytic organisms. When this occurs there is a marked change in constitutional symptoms.

Arrest of Tuberculosis. From the very moment of infection, and while the pathologic changes above described are taking place, the defensive forces of nature are being assembled to combat the progress of the disease. An army of leucocytes is formed and rushed to the seat of conflict. They are employed to invest the enemy and form layer after layer around the infected area. If they are able to turn back the advance of the bacteria they finally institute a state of siege and the disease is said to become latent or quiescent. By a process of condensation called fibrosis, this limiting wall is converted into dense cicatricial tissue, through which the fluid portion of the caseous material is absorbed, the solid portion remaining in the fibrous capsule. Calcification may take place and the mass converted into a nodule of stone-like hardness. The bacilli and their spores are destroyed and the lesion is said to have healed. Occasionally there may later be manifestations of renewed activity of the disease; hence the presence of a quiescent area in the body is always a menace to health, as the bacilli may break forth, become largely disseminated, and give rise to miliary tuberculosis.

Extension of Tuberculosis. From an initial lesion of infection, tuberculosis may extend either locally or systemically. Locally it progresses by contiguity of tissue, as when tuberculosis involves first the epididymis, then the seminal vesicles, the prostate, the bladder, the ureters and the kidneys. Systemic infection may result, first by the blood stream, due to a caseating tubercle opening into a vessel, in which case dissemination is usually widespread; second, by the lymph stream, as is seen in the downward extension of the disease in the lymph nodes of the neck, following infection of the tonsils; and, third, through other currents of the body, as the bladder becoming infected from a tuberculous kidney by the flow of urine, or the intestines becoming involved from the vicious habit of swallowing tuberculous sputum. In cases of systemic infection, it is not always possible to demonstrate the initial lesion, although undoubtedly it invariably exists. A guinea pig may be fed on tubercle bacilli, develop tuberculosis in the mesenteric nodes, and not show a point of tuberculosis in the alimentary tract. A child may drink infected milk, develop tuberculosis of the mesentery and autopsy may show no lesion in the bowel. A patient may have tuberculous lymph nodes of the neck, due to infection through the mouth, and it may be impossible to find any history or evidence of the *portio invasionis*.

LECTURE XXIX.

SURGICAL TUBERCULOSIS (CONTINUED)—CAUSES, SYMPTOMS, DIAGNOSIS, PROGNOSIS AND TREATMENT.

The etiology of tuberculosis is a subject of great theoretical interest, and practical importance, as on it depends not only the prevention, but, to a large degree, the cure of the disease.

The Essential or Exciting Cause of tuberculosis is the bacillus of Koch, which has been described in the previous lecture. The organism is so widely distributed that every one is almost daily exposed to infection. It cannot enter the body except through an infection atrium, which may exist on the skin or in the respiratory, digestive or genito-urinary organs. Surgeons in their daily work are sometimes inoculated through abrasions on their hands. Nurses and attendants upon phthisical patients constantly inhale air laden with the dust of dried tuberculous sputum. Babies are often fed milk from tuberculous cows, and men and women frequently cohabit with partners affected with tuberculous lesions of their genital organs. Some exposed to one or more sources of infection escape, while others, under the same conditions, contract the disease; and hence it is necessary to discuss the factors which give immunity or predisposition.

PREDISPOSING CAUSES.

(1). *Heredity or Environment.* There is no theory more deeply rooted than the belief that consumption runs in families. It is not confined to the laity, but is acted on practically by insurance companies and is taught by most medical authorities. There are three possible explanations of this fact which must be admitted:

(*a*) The direct transmission of the germ from parent to child at conception is believed by some. This is not probable, for the only way the father could infect the child would be through the spermatozoa, and tuberculosis of his genital organs would almost certainly render him sterile or impotent. The only way the mother could convey infection would be through the uterus and its adnexa, or through her blood. This is not probable, because local disease would render her barren and the germ in her blood could not pass the almost perfect filtration of the placenta. Granting, for the sake of argument, however, the possibility of the child being directly infected while *in utero* with the germs or sporesof the disease, it requires a strong stretch of faith to believe that there would be no early manifestations of the disease, but that often it would remain quiescent until its victim had reached the twentieth or thirtieth year.

(*b*) There is a widespread belief in the theory of transmission from parent to child of some predisposition or susceptibility to the disease due to an anatomic or physiologic peculiarity of tissue, so that if the individual comes in contact with the germ in after life, the disease is more liable to be contracted than would be the case of another child not so cursed by heredity. By some of those who hold this theory, it is claimed that there is a peculiar defect in the anatomic arrangement of the lymphatic, circulatory or respiratory system of the patient, but this cannot be demontrated by the scalpel or microscope. By others it is believed that the physiologic resistance inherent in tissue, by which the action of the specific organism is combated, is diminished or absent, and this view, while not capable of demonstration, has much to make it plausable.

(*c*) Some make the bold claim that early environment and not heredity is the explanation of the fact that the disease occurs in successive generations of the same family. Those who hold this view claim there is no such thing as predisposition to tuberculosis—that one individual is not more susceptible to the disease than another, but that it occurs more frequently in some families than in others because of the greater opportunity of infection. They claim that children of tuberculous parents live in a germ-laden atmosphere, that they are nursed and kissed by tuberculous mothers, play with tuberculous brothers and sisters, crawl on a floor soiled with tuberculous sputum and eat food contaminated with tuberculous material.

(2) *Acquired Predisposition.* Leaving the subject of predisposition due to heredity or early environment, we next consider predisposition acquired in after life. Under general causes may be considered factors which produce debility or lowered vitality, such as infectious diseases, anemia, emaciation, and exhausting illnesses from which recovery is prolonged and imperfect. Work, worry, sexual disorders, and a sedentary life with its constant deprivation of fresh air, sunshine and exercise are important predisposing causes. Among the local causes which favor the development of tuberculosis at a certain point may be mentioned anatomic peculiarities, such as exist in epiphyses of growing bone, and the influence of trauma, which not only creates an infection atrium for the entrance of the germs, but lowers the local resistance of the tissue, and enables them to effect localization and produce their characteristic reaction.

Symptoms of Tuberculosis. The general or constitutional symptoms of tuberculosis are more or less similar, no matter where the local process be situated, because they are dependent upon the same factor—namely, the absorption and specific action of the toxins of the germ. There is loss of appetite and disturbance of the digestion, which soon results in lassitude and a sense of exhaustion upon slight exertion. This is followed by an abnormality of the temperature commonly spoken of as "hectic fever," which is characterized by the fact that the temperature is below normal in the morning, but elevated in the evening. The patient awakes weak and depressed, the skin is cold and pallid, the pulse feeble, and a thermometer will show that the temperature is about 97° F. As the day wears on strength returns, together with buoyancy of spirit, and in the evening muscular power is strong and vigorous. The brain is quick and active, the face flushed, the eyes clear and sparkling, and the patient, stimulated and exhilarated by fever, shows such strength and vivacity as to deceive any one save a trained observer. The thermometer at this time will show a temperature of 101° to 102° F. This condition, especially when associated with a constantly increased frequency of the pulse rate, is characteristic of the disease, and should lead to rigid examination to detect the local focus. Anemia is a constant symptom of tuberculosis, and has given to the disease the name of the "Great White Plague." Night sweats soon develop, produced partly by the specific property of the toxins, but aggravated by the weakness of the patient. Thus there is a vicious circle—the weakness producing the sweating, and the sweating intensifying the weakness. Pyogenic infection is often an early complication, adding to the toxemia of tuberculosis that of suppuration, and degenerative changes—especially of the amyloid type—take place in the liver, kidneys and spleen. Emaciation is steady and progressive; obstinate diarrhea develops, the patient becomes bedridden, and finally dies from general exhaustion.

Diagnosis of Tuberculosis. In the majority of cases there is not much excuse in failing to make a diagnosis of tuberculosis. Usually, when an error is made, it is due to ignorance or lack of thoroughness. Not all of the different methods to be described are applicable in every case, but a combination of some of them is always possible and sufficient to warrant a correct solution of the problem. *The family history*, while only suggestive and never positive, should always be ascertained. It is a fact that consumption runs in families, whether it be due to heredity or environment. *The personal history* of the patient should be thoroughly studied, and the various facts with reference to previous occupation, illness, injuries, appetite, strength and weight ascertained. *The general and local symptoms* should be elicited by intelligent cross-examination and an effort should be made to build up an orderly train of facts from the beginning of the trouble until the present time. Such a connected array of data presents a more striking picture, no matter what the disease, than a jumble of disconnected facts. *A thorough physical examination* should be made. It is a mistake to believe that patients object to any necessary amount of exposure or to prolonged and repeated physical examination. They come to the doctor to be cured, and the more they are inspected, thumped and handled, the more they are impressed with the effort being made to locate their trouble. *The Roentgen ray* has a decided field of usefulness. The fluoroscope is often more satisfactory than the radiograph, since different parts of the area under investigation can be readily and rapidly compared. A mass of tuberculous material usually casts a shadow darker than normal structures, while cavities show as lighter areas. *The use of tuberculin* may often be resorted to in certain cases with benefit. This product was introduced to the profession by Koch as a remedy which he hoped would prove a cure for the disease. It has been found of little value in treatment, but has established for itself a strong place as a diagnostic measure. The initial dose advised by Butler is one milligram, approximately .015 of a drop. It is injected hypodermically, and if tuberculosis is present the temperature will rise within ten or twelve hours to 102 to 104° F. If there is no reaction, a double dose is given two or three days later, when, if the result is again negative, the possibility of tuberculosis may be dismissed. A more recent and apparently equally efficacious method of employing tuberculin is by application of the substance to the conjunctiva. *The microscopic examination* of sputum, pus, urine or other products should always be made in suspicious cases, and the absence or presence of the characteristic histologic structure of the tubercle or of the essential bacillus is a factor of weighty importance. *The inoculation of animals* susceptible to the disease, such as the guinea pig, must sometimes be resorted to, when the positive or negative result in the death or continued health of the animal will often settle the question. This is especially true of tuberculosis of the kidney, where germs, if present in the urine, are so few and widely scattered as to make microscopic examination uncertain; also, in cases where there is question of whether the disease is tuberculous or syphilitic. Here the histological structure of the tissues is often so analogous that they cannot be differentiated by the microscope—a sure and certain distinction can be made, however, because, if tuberculous, inoculation of the guinea pig, will cause its death in from five to six weeks, with lesions unmistakable at autopsy; while if it is syphilitic, the animal will show no symptoms, but continue in good health, since it is immune to the disease.

Prognosis of Tuberculosis. The prognosis depends upon the stage of the disease at which the diagnosis is made—the earlier the better; upon the location of the disease—its accessibility to treatment and the possibility of surgical removal; upon the rapidity with which the disease has progressed in the past, and whether it is still local or has become systemic; upon the age and general health of the patient; the state of his appetite, condition of his digestion, and his ability to lead an outdoor life; upon the financial status, mental intelligence, and the attitude of the patient towards the disease. No combination of circumstances is more unfavorable than indigence, ignorance and indifference.

Treatment. The treatment of tuberculosis naturally divides itself into the non-surgical and the surgical methods, the first endeavoring, by proper hygiene and the use of drugs and sera, to so increase the resisting power of the economy that the infectious agent is destroyed or rendered immune by natural processes. The second seeks, by mechanical means, to either radically remove the primary focus of infection, or, if this be impossible, to leave so little of it that nature can complete the work. The subject is such a large one that only the broad principles can be stated and details have to be left to future consideration or to other treatises.

NON-SURGICAL TREATMENT.

1. *The Hygienic Treatment* consists in fresh air and sunshine, exercise, bathing, proper hours of sleep, simple but nutritious food, cheerful society and a hopeful attitude of mind. Hare says: "The whole point at issue is the building up of vital resistance to such a level that the battle between the invading bacillus and the cells of the body can be waged with victory for the cells. * * * The means by which the greatest degree of vital resistance is obtainable is an outdoor life with exposure to as many hours of sunshine as possible and an abundance of fresh air. No drugs can equal the value of these outdoor agencies. * * * Nor can any drug in tuberculosis equal good food if it is well digested and taken in full amount; and he who disorders the digestion by

drugs is doing his patient more harm than good. A good cook is a better friend to a tuberculous patient than a good druggist."

The so-called Russell treatment by administration of fresh juices from fruits and vegetables in addition to other hygienic and dietetic remedies is rapidly becoming popular.

2. *The Climatic Treatment* is not as important as it was at one time supposed to be. Still, a properly selected place of residence will sometimes turn the balance in favor of recovery. Colorado, Arizona, the Adirondacks, the mountainous regions of Western North Carolina, and the pine hills of Georgia, all afford special and peculiar advantages to the invalid. Never send a patient away from home, however, who is so far advanced as to be doomed to die. If possible, avoid resorts which are common haunts of the victims of the disease. A patient has well expressed it when he said: "I would rather be at home and die at once, than drag out a few more years surrounded by a crowd of coughing, hawking and wasting consumptives."

3. *The Medical Treatment* of tuberculosis must not be ignored, although it is not of great value. There is no drug or combination of drugs which have anything like a specific action on the disease. The bitter tonics, such as nux vomica, gentian and cinchona, may be given for loss of appetite: pepsin and hydrochloric acid for disordered digestion; creosote, guaiacol and cod liver oil for their supposed alterative action; whiskey, beer and wine to save oxygenation of tissue and increase physical strength.

4. *The Serum Treatment* of tuberculosis is still in the experimental stage. The time will unquestionably come, however, when an antitoxin will be discovered which will rank in efficiency with the one now in use for diphtheria. Koch's tuberculin, which was announced prematurely by one of his assistants, was once extensively used, but, owing to the crudeness of the product and the severity of its reaction, it did more harm than good, and for a time it was almost completely discarded. It has now been taken up again and, under more careful methods of preparation and more intelligent selection of patients and in smaller doses, it has been found to possess merits which give it a growing list of advocates.

5. *The Mechanical Treatment* of tuberculous disease consists in measures to immobilize the part so that it may have complete physiologic rest. This could easily be done by confining the patient to bed, but the method cannot often be used, as, owing to the chronicity of the disease, it would entail too great impairment of the patient's general health. Resort must therefore be had to splints, braces and other apparatus which, while immobilizing the limb, joint or spine, will still permit the patient to be up and about in the open air and sunshine.

6. *The Production of Artificial Hyperemia*, as a treatment of tuberculosis, is based upon the belief that inflammation is not a pathologic process, but an effort of nature to resist bacterial invasion, and that the swelling, heat and redness present are the weapons used in the conflict. Bier, who first introduced this method, conceived it from the statement of a well known pathologist, who said that he had never found phthisis pulmonalis in a case of valvular disease of the heart which had produced venous stasis of the lung. The results which have followed the application of this treatment to various forms of surgical tuberculosis, especially of bones and joints, have been most gratifying. The artificial hyperemia is produced in a limb by bandaging it with a rubber constrictor above the focus of the disease, sufficiently tight to retard but not completely obstruct the circulation, and on other parts of the body by means of specially devised vacuum cups. The hyperemia is maintained for one or two hours each day.

Surgical Treatment. Before the advent of the aseptic era, all tuberculous foci, especially abscesses, were regarded as *nolle me tangeri*, owing to the fact that during the weeks or months which elapsed before healing took place, there was the almost certainty of secondary pyogenic infection with disastrous results to the patient. Even today, the best surgeons hesitate to attempt an operation unless it is obviously possible to remove every particle of infected tissue. Therefore, resort often has to be made to conservative methods.

1. *Aspiration, Irrigation and Iodoformization* consist in tapping a collection of tuberculous pus with a trocar and, after

the pus has escaped, irrigating the cavity with water to which sufficient tincture of iodine has been added to give the color of sherry wine, and finally, injecting two or three drachms of a 10 per cent emulsion of iodoform and glycerin. This operation is repeated, if necessary, once a week until finally the cavity heals. The method is simple, often successful, and obviates the danger of infection through an open wound.

2. *Incision and Curetting* consist in freely dividing the tissues over the focus of disease and removing the mass as completely as possible with a sharp spoon. If any doubt exists as to the satisfactory accomplishment of the purpose, the surface may be cauterized with a Pacquelin cautery. The cavity should be irrigated, dried and packed with iodoform gauze. This should be removed and replaced at necessary intervals until the space is obliterated.

3. *Excision.* When the focus is so located as to make it feasible to remove it bodily, excision should be the method of choice. For instance, in tuberculosis of the knee, an arthrectomy or removal of the joint will relieve the patient of the disease and at the same time leave him with a fairly serviceable limb.

4. *Enucleation.* This method implies the limitation of the disease to some structure or organ which can be entirely removed, such as a lymph node, testicle or kidney. When such a condition is found to exist the organ should be sacrificed.

5. *Mutilating Operations.* These, though the reproach of surgery, are sometimes necessary in order to save life. For instance, amputation for diffuse tuberculous osteomyelitis or the extensive destruction of a joint, when the condition is irremediable by less heroic measures is in some cases necessary.

LECTURE XXX.

TUBERCULOUS ABSCESS—TUBERCULOSIS OF THE EYE, EAR, NOSE AND THROAT; OF THE SKIN; OF THE MOUTH, TONGUE, INTESTINES AND RECTUM; OF THE GENITAL ORGANS; OF THE URINARY ORGANS.

TUBERCULOUS ABSCESS.

Tuberculous, chronic, cold, wandering or migratory, abscess are synonomous terms used to designate a collection of tuberculous fluid in tissue. It is unfortunate that the term "abscess" was ever applied to this condition as it has created confusion. Under suppuration we considered acute abscess, and an abscess was there defined as a collection of pus in tissue. A tuberculous "abscess" does not contain pus, but liquefied tuberculous material and is, therefore, strictly speaking, not an abscess. While the confusion is to be deplored, it cannot now be corrected as the employment of the term is sanctioned by long usage.

A tuberculous abscess is sometimes called a chronic abscess because it develops slowly as compared with acute abscess. It is sometimes called a cold abscess because of the absence of the symptoms of pain, heat and redness. It is sometimes called a wandering or migratory abscess because of its tendency to migrate along lines of least resistance and to point on the surface at a region more or less distant from its origin. Surgeons sometimes apply to a tuberculous abscess the name of the anatomical part at which it points. For example, in tuberculous disease of the spine an abscess may point in the lumbar region and is then called a lumbar abscess, or it may gravitate along the iliac muscle to the iliac region and is then called an iliac abscess, or along the psoas muscle to Poupart's ligament and is then called a psoas abscess.

Causes. Tuberculous abscesses never develop as a primary disease, but are always secondary to some pre-existing tuberculous lesion. They are frequently seen in the latter stages of tuberculosis of bones, joints and lymph nodes. The development of a tuberculous abscess is about as follows: The bacillus of tuberculosis gains entrance to the body, effects localization in tissue and produces irritation which results in chronic inflammation and the formation of the characteristic tubercles. These increase in number and size, and owing to local anemia and toxemia, undergo coagulation, necrosis and caseation. Finally, liquefaction takes place and there results an emulsion-like mass of cheesy material, which constitutes what is termed tuberculous "pus." This fluid is highly infectious and will produce tuberculosis if injected into a guinea pig. Yet it is difficult and often impossible to demonstrate the presence of the bacillus in it. This is probably due to the presence of spores which can exist under conditions where the germs themselves could not thrive.

The tuberculous pus in the abscess is surrounded by a protecting wall or membrane formed of pre-existing connective tissue and newly developed granulation cells. When exposed by incision this membrane is found to be a thick, soft, bluish structure, very vascular and infected with many active tubercle bacilli. As the tuberculous abscess grows by peripheral extension the wall of the abscess also grows and finally, in obedience to the law of gravity, it begins to migrate or travel through adjacent tissue along lines of least resistance. Thus, if the abscess begins in a cervical lymph node it may point near the clavicle; if it begins in a dorsal vertebra it may point near the groin, or if it begins in the hip joint it may point on the inner side of the thigh.

Symptoms. The constitutional symptoms are those of tuberculosis in general. The local symptoms, unless complications ensue, are swelling and fluctuation. There is absence of pain, heat or redness, characteristic of an acute abscess. In fact, the overlying skin appears whiter and feels colder than normal, and there is no marked tenderness. Swelling is usually the first manifestation to attract attention, and fluctuation is easily obtained, because there is little inflammatory infiltration of the adjacent tissue. When the abscess comes to the surface the skin becomes livid, is thinned by pressure, and finally gives way, allowing the contained tuberculous fluid to escape. Secondary infection with pyogenic, and, perhaps, saprophytic organisms follows, and the general and local symptoms at once become more acute and grave.

Diagnosis. The diagnosis usually presents little difficulty. There is a history of pre-existing tuberculous disease, the slow development of a fluctuating swelling with the absence of redness, heat and pain. Should there be any doubt as to the nature of the condition, it can be settled by the use of the aspirator.

Prognosis. This depends on the age and general health of the patient, upon the size and location of the abscess, and finally and most important of all, the feasibility of removing the primary focus of disease.

Treatment. The constitutional treatment is that of tuberculosis in general. The local treatment will depend upon the location of the primary focus of infection. If, for example, it be in a lymph node or an accessible bone or joint, then the proper course to pursue is to freely open the abscess, completely dissect out its walls and finally attack and remove the tissue from which it had its origin. If, on the other hand, the primary focus is the body of a vertebra or other region which, owing to its location, can not be completely extirpated, then the abscess should not be incised, as the disease could not be completely removed and the open wound would expose the part to secondary infection and entail disastrous consequences. Under such circumstances, the more conservative course of aspiration, irrigation, and iodoformization should be practiced. The part to be operated upon should be disinfected and a trocar introduced into the abscess cavity. Before doing so the skin should be drawn to one side, so that when it returns to its normal position after the withdrawal of the instrument, it will act as a valve and close the opening. When the fluid has been removed, the abscess cavity should be irrigated through the trocar with a solution of tincture of iodine and, finally, two or three drachms of a sterilized 10 per cent emulsion of iodoform in glycerine injected. The trocar is then withdrawn and the tissues gently massaged, so as to diffuse the iodoform over the entire surface of the abscess cavity. Usually within a week or ten days it will be found that there is a reaccumulation of the fluid and the operation has to be repeated. While the abscess is being treated, as above described, the primary tuberculous focus should also be treated by the most approved methods. Thus if the abscess originated from a tuberculous hip, the patient should be put to bed and Buck's extension applied to the affected limb; if the abscess originated from caries of the spine the patient should be kept recumbent on a hard, flat mattress, or the spine immobilized by a plaster jacket. By the methods outlined many tuberculous abscesses can be cured, which, if unwisely incised, would result in the death of the individual.

TUBERCULOSIS OF THE EYE, EAR, THROAT AND NOSE.

These diseases are surgical, but as they are always referred to a specialist it is only necessary to call attention to their existence in order that they may be recognized when seen.

Tuberculosis of the iris is characterized by the development of grayish tubercles which can be plainly seen through the transparent cornea. The treatment is enucleation of the eye.

Tuberculosis of the middle ear is attended by pain, deafness, and a discharge in which the bacillus will be found. Treatment is by removal of the ossicles and curetting the cavity.

Tuberculosis of the nose and throat is frequently seen secondary to phthisis pulmonalis. By the use of diagnostic instruments the tuberculous inflammation can be plainly demonstrated. Treatment is merely palliative.

TUBERCULOSIS OF THE SKIN.

Tuberculosis of the skin is not as common as might be expected when we consider the area of surface presented, the frequency of abrasions upon it, and the constant exposure to infection with the specific germ. Dermatologists have divided tuberculosis of the skin into many varieties, such as lupus, lupus vulgaris, lupus exedens, lupus non-exedens, scrofulo-derma, and tuberculosis verrucosa cutis. This is totally unnecessary, however, as the essential cause, the pathological changes and the treatment are the same for all.

The fact that tuberculosis of the skin and lupus are identical was suspected before bacteriologists demonstrated the existence of the same germ in each. Clinicians observed, first, that lupus came almost invariably upon the face and hands, where the skin was not protected by hair or clothing, which seemed to show that the disease was due to infection; and, second, that lupus was followed in 50 per cent of cases by tuberculosis of the lungs or other organs, which seemed to prove that one disease was but the beginning of the other. Koch definitely settled the question by making a culture from an unquestioned case of lupus, breeding the germs through fifteen generations in the laboratory and then producing characteristic tuberculosis by the inoculation of guinea pigs.

Pathology. The specific germ gains entrance through an infection atrium, produces chronic inflammation and the development of tubercles. The focus increases in size until finally it approaches the surface and pressure produces ulceration. The wound becomes secondarily infected with pus germs and a large ulcer results.

Symptoms. The disease usually begins in middle life, though no age is exempt. It first shows itself as one or more reddish papules the size of a pinhead. These become aggregated into a nodule, which is not tender and is elastic to pressure. It may break down in the center and the whole mass undergo ulceration (lupus exedens) though less frequently the nodule does not ulcerate and remains stationary for months or years (lupus non-exedens). The progress of the disease is often slow, ulceration and cicatrization keeping pace one with the other, so that the diseased area remains stationary in size.

Diagnosis. This is not always easy, as it is sometimes difficult to differentiate it from tertiary syphilis or epithelioma. There is little difference in histologic structure between the tuberculous nodule and the syphilitic gumma, hence the question cannot be determined by microscopic examination. The history of the case is important, but, unfortunately, we are often unable to get satisfactory information from the patient. If time permits, the point may be settled either by an anti-syphilitic treatment of the patient or by the inoculation of a guinea pig.

The differential diagnosis between lupus and epithelioma is based, first, on the primary location of the disease and the character of the infiltration; and, second, on the microscopic examination of a piece of diseased tissue. Tuberculosis begins in the deeper portion of the skin, while epithelioma starts in the superficial layer. In tuberculosis the margin is infiltrated but is not as hard or dense as in epithelioma. Under the microscope tuberculous tissue shows a total absence of blood vessels, while epithelioma is very vascular in structure, and the cells have a characteristic "nest-like" arrangement.

Prognosis. This is bad unless the case is seen early and treated radically. The disease not only causes horrible disfigurement by local destruction, but ultimately becomes disseminated and produces tuberculosis in distant organs.

Treatment. The internal administration of arsenic seems to do some good. It should be given in large and increasing doses until its full physiologic effect is produced. The surgical treatment should be conducted on the same principles as an operation for the removal of a malignant growth. The diseased tissue should be removed, the incision being made through healthy tissue. If this is impossible the infected granulations should be thoroughly curetted by the vigorous use of a sharp curette. When practicable the raw surface should be covered by skin grafts, thus hastening epidermization. Koch's lymph, which has not proved of decided value in other forms of tuberculosis, frequently does much good in lupus and, therefore, in some cases it should be tried. The X-ray, Finsen's light and radium also have their advocates, and the former is distinctly valuable.

TUBERCULOSIS OF THE MOUTH AND TONGUE.

This disease is not common and when seen usually results from primary infection from tuberculous milk or other infected food. It is of clinical interest to the surgeon mainly from the fact of the liability of mistaking it for syphilis or epithelioma. After effecting localization the germ produces characteristic chronic inflammation which terminates in ulceration. Ulcers form on the tongue, tonsils, hard and soft palate. They are usually flat, oval and covered with a soft, white membrane, which bleeds freely when brushed off. The *diagnosis* of tuberculosis of the mouth and its differentiation from syphilis and cancer is based on the same facts, and is made in the same way, as in lupus. An early enlargement of the submaxillary nodes points rather to epithelioma than to either syphilis or tuberculosis. The *treatment* consists of the radical removal of the diseased tissue. If possible it should be excised with the knife and the wound sutured. If this is not practicable the infected granulations should be destroyed with a curette or actual cautery.

TUBERCULOSIS OF THE INTESTINES.

This is a fairly common disease, especially in children. It may be due to primary infection from food or drink, or to secondary infection from extension of disease from some other focus in the body. The symptoms are vague and ill-defined and consist of pain and a feeling of weight in the abdomen attended by alternating diarrhea and constipation. There is hectic fever, sweating and loss of appetite, strength and flesh. The treatment is usually carried out along medical lines unless obstruction occurs from angulation or stricture of the bowels. Usually the principal seat of trouble is found in the region of the ileo-cecal valve. Resection and anastomosis often prolong life and sometimes restore health.

TUBERCULOSIS OF THE RECTUM.

This is a frequent disease. It is practically always secondary to tuberculosis elsewhere. Three per cent of patients the victim of tuberculosis of the lungs have tuberculous fistulæ of the rectum, supposed to be due to swallowing infectious sputum. These patients cannot be cured, but they are entitled to be relieved and should be operated on if they are not in the last stages of the disease. A tuberculous fistula should be laid open and excised or curetted. Tuberculous proctitis should be treated by irrigation with iodine solution and the local use of iodoform in the form of suppositories or emulsion.

TUBERCULOSIS OF THE VULVA, VAGINA AND UTERUS.

It is only in comparatively recent years that tuberculosis of these parts has been recognized. The possibility of the disease occurring was proved by Cornet, who produced it in bitches by injecting a culture of the germs into their vagina. A woman may develop the disease by direct infection through coitus, or vaginal examination, or through secondary infection from some pre-existing focus.

Owing to the location of the disease on the genital organs it is usually mistaken for syphilis. Careful investigation along lines previously suggested should prevent a mistake. Lupus ulcers on the vulva or in the vagina should be excised, cauterized, or scraped, and tuberculous inflammation of the uterine mucosa calls for vigorous curettage or complete hysterectomy

TUBERCULOSIS OF THE FALLOPIAN TUBES.

This may be due to either primary or secondary infection. A germ in the blood stream or one deposited in the vagina, and ascending, may produce primary infection, or again, the disease may be secondary to tuberculosis of the appendix, intestines or uterus. The local symptoms are not different from chronic inflammation due to other causes; the constitutional symptoms are those of tuberculosis in general. The diagnosis is based on the family history, the physical signs, and sometimes it can be made positive by the presence of tubercle bacilli in leucorrheal discharge. Dudley states that in virgins 90 per cent of salpingitis is due to tuberculosis. The treatment is an abdominal section and the removal of the Fallopian tubes. The uterus should be carefully examined, and if it is involved, a hysterectomy should be performed.

TUBERCULOSIS OF THE GLANS PENIS AND URETHRA.

This condition is rare, but its possibility must be borne in mind in order that it may not be mistaken for syphilis. When the disease attacks the glans penis, a lupus ulcer results, and when it attacks the urethra the mucous lining becomes studded with tubercles, which are easily seen by means of an endoscopic tube. The treatment will depend upon the extent of the disease. If incision, curetting, and local applications do not prove adequate to meet conditions, then a partial or complete amputation of the penis may be necessary.

TUBERCULOSIS OF THE EPIDIDYMIS AND TESTICLES.

This is comparatively a common trouble. Infection may be primary from the blood or through coitus, or secondary from tuberculosis of other parts of the body. Usually the patient accidentally discovers an enlargement at the head of the epididymis. At first it is hard, freely movable and painless. It grows slowly, undergoes caseation and softening, and if neglected, involves, first, the testicle, and then the vas deferens. Ultimately the vesiculæ seminales, prostate, bladder, and at times the ureter and kidney are attacked. The scrotum over the testicle finally becomes adherent, the liquefied tuberculous product approaches the surface and discharges. The sinus does not heal and secondary infection soon follows.

The diagnosis is based on the presence of a painless enlargement in the epididymis, occurring in a man without history of gonorrhea or recent traumatism. If nodules can be felt along the cord or in the prostate or seminal vesicles, there is no question as to the nature of the disease. When liquefaction takes place, and pointing and discharge of cheesy material occurs, the tubercle bacillus can be identified microscopically.

Tuberculous epididymitis never disappears spontaneously—castration is the only cure. This should be done, however, only when there is no evidence of tuberculosis in other organs of the body.

TUBERCULOSIS OF THE SEMINAL VESICLES.

Primary tuberculosis of the seminal vesicles is rare. Secondary involvement by extension from the epididymis and other parts of the genito-urinary system is fairly common. The onset of the disease is insidious, and unless complications develop, the diagnosis is not usually made early. On rectal examination, hard nodules can be felt in the vesicle. If there seems a possibility of completely removing the disease, an operation is justifiable. An incision is made in the perineum, as is done for prostatectomy, and the seminal vesicles enucleated.

TUBERCULOSIS OF THE BLADDER.

Tuberculous cystitis practically never occurs as a primary infection, but is usually secondary to another focus of disease, generally the kidneys. It is more frequent in the female than in the male.

The symptoms are, at first, those of chronic cystitis. They begin insidiously, consisting of frequent calls to empty the bladder, followed by pain and tenesmus. The urine soon becomes admixed with mucus, pus and blood. Persistent bleeding is very suggestive of the disease. Tuberculosis should always be suspected when a young person of a tuberculous family develops cystitis without apparent cause, which does not yield and is not cured by ordinary treatment. In such a case a cystoscopic examination should be made, which frequently shows either the presence of numerous grayish tubercles or the existence of a ragged, punched-out, bleeding ulcer. The urine should be carefully examined, but even in advanced cases it is difficult to demonstrate the bacillis, as they are scanty and hard to find. In doubtful cases, the infectiousness of the urine may be determined by experimental inoculation of a guinea pig.

The *prognosis* of tuberculosis of the bladder is bad. If primary, it is usually not recognized until too late to be radically removed, and if secondary, the patient's general condition and expectancy of life makes it unwarranted to do a radical operation. The *treatment* consists in the internal administration of urinary antiseptics, in irrigating the bladder with solutions of boric acid, tincture of iodine, of bichloride of mercury and generally of nephrectomy. When these measures fail to give relief or if nephrectomy is contra-indicated, a supra-pubic incision should be made for drainage. A few attempts have been made at radical cure by opening the bladder, cauterizing, curretting or excising the diseased area.

TUBERCULOSIS OF THE KIDNEYS.

Usually the kidneys are infected primarily through the blood, but sometimes the condition is secondary to disease elsewhere.

The symptoms consist in pain in the back extending down the ureter to the bladder. The urine is constantly of low specific gravity, contains pus and is acid in reaction. A definite diagnosis can be made by the cystoscope and the use of the ureteral catheters.

When only one kidney is involved, the treatment consists in a nephrectomy, with the removal of as much of the ureter as possible. When both kidneys are affected, the best that can be done is to do a nephrotomy to drain the pelvis and afterwards irrigate with iodine solution.

LECTURE XXXI.

SURGICAL TUBERCULOSIS (CONTINUED)—TUBERCULOSIS OF THE PERITONEUM—TUBERCULOSIS OF LYMPH NODES—TUBERCULOSIS OF TENDON SHEATHS.

TUBERCULOSIS OF THE PERITONEUM.

This is a frequent disease, occurring, according to most authors, twice as often in the female as in the male. In rare instances it may be primary, the infecting organism being transported by the blood, but in most cases it is secondary to tuberculous processes in neighboring structures, such as the bile tract, the appendix, or the Fallopian tubes. Novak states, "By far the large majority of cases of tuberculous peritonitis are secondary to tuberculous processes elsewhere in the body," and Borschke, in 226 autopsies, found the disease primary in only two cases. William J. Mayo states that practically all cases of tuberculous peritonitis are due to extension of the disease from the appendix or Fallopian tubes, and explains the greater frequency of the disease in women as compared to men by the fact that in addition to the appendix, common to both, the woman has also the Fallopian tubes.

Varieties. Clinically, we recognize three different types of tuberculous peritonitis, and although, as Osler maintains, they may represent merely different stages of the disease, it is important to classify them, because the first form is more amenable to treatment than the other two.

1. *The Ascitic Form.* In this type the abdominal cavity is more or less filled with a clear, transparent serum, and the peritoneal surfaces are studded with numerous grayish tubercles. The fluid may be free and occupy the general cavity, or it may be confined and localized by adherent bowel and omentum so as to make a cystic swelling.

2. *The Fibrino-plastic Form* is that in which there is no fluid in

the abdominal cavity, but the peritoneal surfaces are studded with tubercles and covered with a thick layer of gelatinous fibrin. The abdominal organs are embedded in a glue-like mass so that it is difficult to determine their outline.

3. *The Adhesive Form* is characterized by the absence of fluid or gelatinous material, the inflammation causing tissue proliferation, which, undergoing cicatrization, unites the abdominal viscera by the densest adhesions.

Symptoms and Diagnosis. In the majority of cases the early history and symptoms are indefinite. There is usually some tenderness and pain in the lower abdomen, attended by alternating constipation and diarrhea. As a rule, there is a slight evening rise of temperature, although Osler claims that subnormal temperature extending over months is sometimes seen. After a time, enlargement of the abdomen may be noticed. If there is free fluid in the peritoneal cavity, the physical signs will be simply those of ascites; and in making a diagnosis, the existence of cirrhosis of the liver, cardiac or renal disease and cancer of an abdominal viscus must be excluded. If the fluid is circumscribed by adhesions, the physical signs may resemble those of pyo-salpinx, ovarian cyst, hydro-nephrosis or gall bladder disease. It is a fact that more cases of tuberculous peritonitis are opened under a mistaken diagnosis than are operated on with a correct appreciation of the nature of the trouble. This, however, is a matter of little moment, as the treatment is surgical, and no operator should open the abdomen who is not competent to deal with any condition he finds.

Prognosis. In 1862 Sir Spencer Wells did a laparotomy on a supposed ovarian cyst but finding the condition to be localized tuberculous peritonitis, he closed the abdomen. Much to his surprise the patient recovered and remained well. Since that time numerous operations have been done for tuberculous peritonitis, some intentional and other unintentional, and the success that has followed them has been as gratifying as it is inexplicable. All authors report the acsitic variety as being the most favorable for operation and, fortunately, this type constitutes 68 per cent of the whole. Aldibert reports 82 per cent cures; Ochsner 84 per cent; Roersch, 75 per cent; Maurange, 80 per cent and Galvani, 86 per cent.

Treatment. Unquestionably, some cases of tuberculosis of the peritoneum recover under hygienic and medicinal treatment. It is generally recognized, however, that surgical intervention is the proper course in the ascitic type of the disease.

When the operative treatment first came into vogue, surgeons opened the peritoneal cavity, irrigated it with antiseptics, dusted it with iodoform, and drained it with tubes or gauze. One by one these various procedures were omitted and it was found that the patients did as well or even better, without irrigation, iodoformization or drainage as they did with them. The present practice is simply to open the abdomen, evacuate the fluid, and close the incision. Mayo, while admitting that opening the abdomen and removing the fluid will cure a large percentage of patients, advises a careful examination of the appendix and Fallopian tubes and their removal if they are found to be involved by the tuberculous process. He states that before he adopted the plan of removing the appendix or tubes, a large number of cases would come back on account of a reaccumulation of fluid. On the other hand, "of twenty-six radical tubo-ovarian operations done for the cure of this condition, twenty-five recovered, and in none has any further operation been necessary. Of these twenty-six cases, seven had been previously operated on by simple laparotomy from one to four times."

There are many theories to explain the cure of tuberculous peritonitis by an operation: First, the traumatic effect of the laparotomy; second, the contact of the air with the peritoneum; third, the formation of adhesions which act as a protective to the absorbing surface; fourth, the action of radiated sunlight; fifth, the introduction into the peritoneal cavity of microbes antagonistic to the bacillus of tuberculosis; sixth, the diminution of intra-abdominal pressure, causing better heart and lung action; seventh, the psychical influence of the operation; eighth, the reflex action produced by handling the peritoneum; ninth, the inflammatory reaction created in the peritoneum, with encapsulation and absorption of the bacilli; tenth, the flow of fresh serum into the peritoneum which follows the relief of tension. These theories have been collected and published by Abbe, but none of them will stand the test of criticism. Mayo believes that an operation cures because the withdrawal of the fluid allows the fimbriated ends of the Fallopian tubes to collapse and adhere to surrounding structures, instead of floating in the fluid, as before the operation, thus sealing the tube and preventing the escape of serum from it into the abdominal cavity. This can not be true, however, as paracentesis abdominalis or tapping accomplishes the same end—it removes the fluid, and yet it is not followed by anything like so large a percentage of cures. At this time it must be admitted that while we can cure tuberculous peritonitis by an operation, we do not know how we do it.

TUBERCULOSIS OF LYMPH NODES.

Tuberculosis of the lymph nodes or tuberculous lymphadenitis are correct terms for the "scrofular glands" of the old writers. It is an exceedingly frequent disease, occurring perhaps as often as pulmonary tuberculosis. It is usually seen in the young, is more common in the negro than in the white, and is more apt to attack those living in the city than those dwelling under more healthy conditions in the country.

Causes. The essential cause is, of course, the bacillus of tuberculosis. The disease was once thought to be a local manifestation of a general infection, but now it is well established that it is primarily local and only becomes general by extension. About one-third of patients suffering from the disease give a family history of tuberculosis, but this merely indicates that they have inherited a tendency to the disease which renders them easy victims when infection takes place.

Pathology. The tonsils, the naso-pharynx, a carious tooth, or an eczema of the face or scalp are the usual portals of entry for the infection. Once gaining entrance to the lymph circulation, the germs are swept on through the lymph channels until a lymph node is reached, when localization takes place and specific lymphadenitis results.

The physiologic function of a lymph node is to oppose the progress of an infectious agent through the lymph stream, and, true to its duty, the node obstructs the onward progress of the disease until it is seriously injured or completely destroyed. Finally, however, the node breaks down and no longer acts as an efficient filter, and the germs pass through it and reach the next one of the group. Unless the resistance of the body is sufficient to encapsulate the disease, or secondary infection takes place with destruction and removal of the tuberculous tissue by suppuration, or relief is afforded by a timely surgical operation, one by one the neighboring nodes become involved and their resistance overcome, until finally the general circulation is reached and miliary tuberculosis results.

Symptoms. Tuberculosis always attacks the lymph nodes nearest the point of inoculation. In 90 per cent of cases the infection atrium is on the face or in the mouth and, as a consequence, the cervical nodes are the ones affected. It must be remembered, however, that the axillary, inguinal, mediastinal, and mesenteric groups are also sometimes involved. As cervical lymphadenitis is the form most frequently seen it will be described as illustrative of the whole.

As might be expected, the first nodes to be affected are between the angle of the jaw and tip of the mastoid process. From this as a primary focus, there is descending infection down the neck, one node after another being involved. When the patient is seen the primary node may be the size of a walnut, while the last one of the chain perceptibly diseased is scarcely larger than normal. The nodes in the early stages are hard, painless and easily movable. In time, however, they undergo caseation, become soft and fluctuate. Several nodes may become adherent to each other and to adjacent structures and form a fixed, irregular mass. After the caseous material perforates the capsules of the node it infects other structures and a tuberculous abscess results. The "pus," now unrestrained, dissects its way through connective tissue planes up and down the neck, and finally ruptures through the skin, to discharge by a fistulous tract at a point sometimes as low down as the clavicle. Secondary pyogenic infection is likely to follow, and with its development comes the septic symptoms of phlegmonous inflammation.

The rapidity of the progress of tuberculous lymphadenitis is very variable. It may be acute and shortly result in systemic infection; it may be chronic and continue for months; or it may be arrested for years and suddenly take a new activity.

Differential Diagnosis. Simple adenitis develops quickly and the enlargement promptly subsides when the irritant is removed. Suppurative adenitis is attended by pain, redness, and the formation of pus. Syphilitic adenitis is not confined to one region, but exists throughout the entire body. Carcinomatous enlargement of lymph nodes is secondary to the carcinoma, and the presence of the neoplasm is diagnostic. A lymphoma is a benign tumor involving a single lymph node. Lympho-sarcoma and pseudoleukemia are both attended by cervical enlargement, but in the first the swelling is that of a tumor and does not undergo softening and discharge, while the second is attended by more or less characteristic blood changes. When in doubt, a positive diagnosis can be made by use of the tuberculin test, or by a microscopic examination of the diseased tissue.

Prognosis. Tuberculosis of lymph nodes is not of itself fatal. It kills by extension and systemic infection. Spontaneous healing is possible in all stages by encapsulation, or by destruction of the diseased tissue by pyogenic infection. This, however, should not be expected. The prognosis may be stated as dependent on the age and general health of the patient, the progress of the disease, and the method of treatment adopted.

Treatment. The constitutional treatment is that of tuberculosis in general, and consists in an effort to increase the patient's resistance by an improvement in his general health.

The local treatment usually includes painting the affected region with iodine, which is worthless, and rubbing the parts with liniments or ointments, which is dangerous. The surgical treatment consists in the complete removal of the diseased nodes. The argument in its favor is so strongly stated by Senn that it is given in his own words: "Early operative interference is as necessary in the treatment of tuberculous adenitis as in the treatment of a malignant tumor, and holds out more encouragement so far as permanent cure is concerned. By a thorough removal of the primary foci of infection, successive infection of proximal glands and general miliary tuberculosis are prevented almost to a certainty, if the operation is performed before the disease has extended beyond the capsule of the glands. If the operation is done at such a favorable time, it is not attended by any great difficulties other than those of anatomic relations. As the glands can be readily excised, and as suppuration has not taken place, the wound usually heals by primary intention."

For the technique of the various operations for the removal of tubercular nodes in the different regions of the body, the student is referred to textbooks on the practice of surgery. The success of these operations will depend upon the completeness with which the nodes are removed, and their safety will depend upon an exposure so complete as to enable the surgeon to demonstrate, not only by touch but also by sight, the various structures in his field of operation. As a type of the methods employed by modern surgeons in dealing with this condition, may be mentioned the admirable operation for removing tubercular nodes of the neck, introduced by Dr. James F. Mitchell, of Washington, who makes a long incision beginning behind the ear over the mastoid process, curving forward over the edge of the sterno-mastoid muscle, and then slightly backward to the middle of the clavicle. A transverse incision is then made along the collar bone, forming a T. The skin is dissected back, giving a large quadrilateral exposure, through which all parts of the neck can be reached, even the submental region.

TUBERCULOSIS OF TENDON SHEATHS.

Tuberculous teno-synovitis was formerly thought to be always secondary to tuberculosis of a neighboring joint. It is now, however, recognized that it occurs as a primary disease. It is an interesting fact to note that nine times out of ten when it does occur it is found affecting the tendons in the neighborhood of the wrist.

The disease occurs in three forms. In the first there is the production of exuberant granulations upon the inner surface of the sheath, which imparts a peculiar creaking sound and friction upon examination. In the second there is an outpouring of clear serous fluid, producing a hydrops of the tendon sheath. In the third there is the presence of small, hard, white bodies resembling grains of rice, called *corpora ryzoidea.*

Symptoms. When one of the tendons about the wrist is involved, a slow, painless swelling results, which extends along the tendon, sometimes up the forearm to about its middle, or down beneath the annular ligament into the palm of the hand. In the fungous variety there is no fluctuation, but the swelling is more or less elastic. In the hydrops form fluctuation is a characteristic symptom. When the rice bodies are present crepitation can be felt.

Diagnosis. This is not usually difficult and is based on the swelling, slow in formation, unattended by pain, and corresponding with the known anatomical position of the tendon sheaths. It can be differentiated from ordinary ganglion about the wrist, because the latter is more or less spherical and strictly localized, and, on incision, is found to contain a thick, tenacious, honey-like fluid. It can be differentiated from teno-synovitis the result of injury, as the latter is an acute process attended by pain, and usually shortly undergoes a spontaneous cure.

Treatment. The treatment for tuberculous teno-synovitis should consist in radical operation and the removal of the infection, while it is yet local. The limb should be rendered bloodless by an Esmarch's bandage and constrictor, an incision should be made and the tendon sheath opened. The cut should be enlarged up or down as far as necessary to expose the disease, but if the anterior annular ligament is divided, it should be carefully sutured at the close of the operation. The granulations should be thoroughly curetted, and if this is not deemed sufficient, the tendon sheath should be excised. The wound should be irrigated with iodine solution, the constrictor removed, hemorrhage controlled, the incision sutured, and the part immobilized on a splint.

LECTURE XXXII.

SURGICAL TUBERCULOSIS (CONCLUDED)—TUBERCULOSIS OF BONES AND JOINTS—PATHOLOGY, ETIOLOGY, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT.

Tuberculosis of bone is very common, especially in children and young adults. It usually attacks the epiphyseal extremity of long bones, although it is sometimes seen in the vertebrae, carpus, tarsus, scapula, and ilium.

Pathology. The infection may be conveyed to the bone by a single organism floating in the blood or by an embolus from a disintegrating tuberculous lymph node. Localization usually takes place in the neighborhood of the epiphyseal line, which has already been spoken of as the "zone of pathologic election," being especially susceptible to disease owing to the imperfect development of the growing cells and the tortuous condition of the blood vessels. The embolus usually lodges in a terminal vessel and as a result a triangular area of bone is rendered ischemic. Tuberculous inflammation follows with death of bone and the formation of a sequestrum.

Practical surgeons have frequently noted the fact that tuberculous sequestra are nearly always wedge-shaped. Konig, before experimental research confirmed him, assigned as the reason for this peculiar and constant shape of necrosed bone, the occlusion of a small artery by embolus, and Müller confirmed the clinical findings and pathologic reasoning by injecting tuberculous pus directly into the nutrient artery of bone, and upon subsequently killing the animal, demonstrating that the disease was found localized in triangular areas at the articular ends of bone.

After causing death of bone, the bacillus of tuberculosis and its toxins, by some peculiar property inherent in them, bring about decalcification, which removes the lime salts and leaves merely a shell-like fragment. This causes the characteristic worm-eaten or honeycomb appearance of the sequestrum of tuberculous bone, and to this process is given the technical name of osteoporosis. Opposing this destructive process of disease is a conservative process of nature consisting in condensation and hardening of the bone around the area of infection, so that it becomes dense, and non-absorbent, and by it the infection is shut in by a more or less impenetrable wall, and to this process is given the name of osteosclerosis.

Causes. The essential cause of the disease is, of course, the bacillus of tuberculosis. This has been demonstrated by the constant association of the germ with the disease and by the ability of experimenters to artificially produce the disease by inoculation.

The predisposing causes are traumatism and age, both giving rise to conditions favoring the localization and development of the disease. Almost without exception the mother will date the origin of tuberculosis trouble in a child to a fall or blow. Volkmann says it is characteristic for traumatism to have been a slight one. It is a fact, that even in a tuberculous subject, the disease does not follow a severe injury such as a fracture. The explanation of this is that after a slight trauma, the injury is so insignificant that nature does not repair it, while after a severe trauma there is such active cell proliferation to repair the gross damage, that germs, even if present, are unable to effect localization.

Age is another predisposing cause of the disease, inasmuch as in childhood and adolescence bone is rapidly growing and the embryonal cells, with their peculiar vascular supply, present much less resistance to infection than do the bones of an adult after complete ossification takes place.

Symptoms. There is usually a slight rise of evening temperature and a slow, progressive anemia. It is upon the local symptoms that a diagnosis must be based and they are as follows:

1. Pain. This is a constant symptom. It is usually described as dull, boring or gnawing in character, its severity depending on the acuteness of the disease. It is markedly in-

creased by passive manipulation or exercise, and diminished by physiological rest of the part. Nocturnal exacerbation is characteristic. The child may not complain of pain while awake, but after going to sleep he will be restless, cry out, grind his teeth and otherwise show his suffering. The pain is not always referred to the seat of inflammation, as, for example, in caries of the spine, the pain is in the abdomen, and in tuberculosis of the hip, at the inner side of the knee.

2. Tenderness. This is perhaps the most reliable symptom, as it localizes the seat of the disease, determines with some accuracy the number of foci and shows the area of tissue involved. As stated, the disease usually begins near the extremity of long bones, and the child usually complains of pain in the adjacent joint. Careful palpation and the determination of the point of the greatest tenderness will determine whether the case is one of osteomyelitis or synovitis.

3. Swelling. This is absent in the early stages of the disease just as it is in suppurative osteomyelitis. Swelling does not occur until the inflammatory process penetrates the cortex of the bone and involves the overlying soft structures. The surgeon who does not make a diagnosis and apply his treatment until swelling appears loses the golden opportunity to arrest the disease before extensive destruction ensues.

4. Redness. This, too, for the same reasons, is lacking in the early stages and has only a negative diagnostic value. It develops shortly after swelling appears, the skin becoming discolored, thinned, and finally perforated, allowing the escape of tuberculous pus.

5. Atrophy of the Part. This is characteristic and dependent partly on lack of use, but more upon some obscure interference with the function of the trophic nerves of the part.

Diagnosis. This is based upon the age, history and local symptoms and, in doubtful cases, may be confirmed by a method which has received the formidable name of akidopeurastik, a tongue-twister applied by its German originator to mean the perforation of the bone cavity with a hollow needle, and the aspiration and examination of the material it contains.

Treatment. 1. Physiologic Rest. The importance of rest to the inflamed part can not be overestimated, and no matter what other treatment is applied, the part affected should be immobilized and relieved as far as possible of its physiologic duty.

2. Igni-puncture. If the focus can be accurately located early in the disease, puncture with the actual cautery heated to a cherry-red heat is very efficacious. It destroys the organisms, rouses the resisting forces of nature to activity, and the opening serves as a drainage tract, relieving tension and allowing escape of retained fluids.

3. Iodoformization. Iodoform has an inhibitory effect upon tuberculous disease; hence if the focus is accessible, it should be injected with a 10 per cent emulsion of iodoform in glycerin and the treatment repeated if improvement follows.

4. Passive hyperemia by Bier's method is now popular and when properly applied is a useful adjunct to other methods of treatment.

5. Radical Operations. If rest, igni-puncture and the use of iodoform prove inefficient or are not considered adequate to meet conditions, then more heroic methods must be applied. The part should be rendered bloodless with an Esmarch's bandage, the soft overlying structures incised and the bone exposed. With chisel and mallet the tuberculous cavity should be opened by cutting away the hardened bone encasing it, and the sequestrum removed. In advanced cases it may be necessary to excise the entire shaft of the bone or to amputate the limb.

TUBERCULOSIS OF JOINTS.

Tuberculosis of joints, tuberculous arthritis, white swelling, chronic fungous arthritis, and scrofulous joints are synonymous terms applied to tuberculous inflammation of a joint. The hip, knee, vertebræ, ankle, elbow, shoulder and wrist joints are the ones most frequently diseased. Infection may occur in two ways: first, by extension of inflammation from neighboring bone into the joint, giving rise to what is known as "primary osteal" arthritis; second, by the localization of a blood-borne organism in the synovial membrane of the joint, thus producing what is termed "primary synovial" tuberculosis of the joint. The primary osteal form of the disease occurs two or three times as frequently as the primary synovial form, but the distinction between the two, while theoretically of interest, is of practically little moment as disease of one structure always, sooner or later, extends to the other.

Pathology. The bacillus of tuberculosis having reached the synovial membrane either through the circulation or by extension from a primary focus in the articular end of a bone, is soon widely disseminated over the entire surface of the joint by means of the synovial fluid. As a result there is development of a chronic inflammation which, unless arrested, involves every structure of the part, and finally bursts through the capsule of the joint to continue its ravages in the periarticular tissues. The inflammatory product may take on one of two forms: (1) There may be little transudate but a great deal of exudate. As a consequence there is little or no fluid in the cavity but the synovial membrane is much thickened and becomes soft and pulpy. This is the fungous arthritis or *tumor albus* of the old writers. (2) There may be but little exudate but a great deal of transudate, and the synovial sac is filled with a large amount of fluid containing rice-like bodies, giving rise to the so-called dropsical form of the disease.

Causes. The essential cause is, of course, the bacillus of tuberculosis. Among predisposing causes, traumatism is the most important. A careful study of a large number of cases has shown that 56 per cent of them can be traced to some injury, such as a blow, twist or over-strain of the joint. The traumatisms are usually slight, for the same reasons as those given in the section on the etiology of tuberculosis in bone. One-half of all cases occur before the twentieth year, due to the frequency of tuberculosis of bone in children, and this despite the fact that tuberculosis of the wrist and of the shoulder are rarely seen except in the adult.

Symptoms. The patient may exhibit a slight rise of evening temperature, followed later by sweating, pallor and emaciation, but often there is no depreciation of the general health and a diagnosis must be based entirely upon the changes in the joint itself. The local symptoms are very distinctive and consist in:

Swelling. This is so characteristic that the disease is often spoken of as "white swelling." The joint is not only enlarged by the hydrops or the excessive granulations, but the muscles of the limb above and below the joint are atrophied by disuse and tropho-neurosis to such an extent as to make the joint appear larger than it really is. Upon examination the bony landmarks will be found obscured or lost and fluctuation can be obtained. In the dropsical form the swelling is due to the presence of fluid; in the fungous variety it is caused by the thickening of the capsule from the exuberant granulations. These new cells are so soft that there is apparent fluctuation in the fungous form as well as in the dropsical, and it is often necessary to use the aspirator to determine whether the swelling is due to fluid or solid material. When the disease has extended through the capsule into the periarticular tissue, the swelling becomes even greater and the joint assumes a spindle shape. As the inflammation approaches the surface and the subcutaneous tissues are involved, the skin becomes white, dense and immovable, and then it is that we have the typical "white swelling."

Pain. This is rarely marked in degree. It is subject to nocturnal exacerbation. The fungous form of the disease gives less pain than the dropsical, as the granulations are insensitive and protect the surfaces they cover. Primary synovial tuberculosis is often unattended by pain until the process extends through the cartilage to the bone, while on the other hand the osteal form is attended by pain from the beginning, no increase being noted when the joint is invaded.

Rigidity and Deformity. This is greater in the fungous than in the dropsical form. The joint is usually flexed because, first, this position increases the capacity of the capsule and lessens pain; and second, the muscles involuntarily contract to prevent motion, and the flexors being stronger than the extensors, flexion is the result of two forces. Pathologic dislocation is often seen in the late stages, due to destruction of essential parts of the joint, allowing change in the normal relation of the bones which compose it. Ankylosis is also sometimes observed, due to reparative change inaugurated by nature after the destructive process has run its course.

Diagnosis. This is usually easy and is based on the age of the individual, the characteristic deformity and the presence of patholgnomic symptoms peculiar to the disease when it attacks individual joints.

Treatment. Physiological Rest. This is the most important indication to be met, and if properly applied in the early stages will cure 95 per cent of all cases. It is carried out by means of confinement to bed, fixation by mechanical appliances, and the use of extension in order to avoid friction between the opposed surfaces of the joint. During the acute stages of hip-joint disease the child should be put to bed, the limb immobilized by sand bags or other dressing, and Buck's extension applied with enough weight to overcome muscular contraction and to prevent the head of the femur grinding in the acetabular cavity. When the acute symptoms subside it is advisable to allow the child to leave the bed and get in the open air, but immobilization and extension must be continued by means of suitable apparatus.

In tuberculosis of the knee, physiologic rest must be secured by perfect fixation of the joint, and the effort to effect a cure by this means must not be despaired of even if improvement is not apparent for months or years. The mistake usually made in handling such cases is the too frequent change of the plaster cast.

In tuberculosis of the spine, physiologic rest should be secured by the application of a properly fitted Sayer's plaster jacket, provided the patient be sufficiently developed to have hips prominent enough to bear its weight. In children under five years of age this method is not sufficient, and temporary resort must be had to the recumbent position on a hard, flat mattress. Immobilization should be the treatment for all cases of joint tuberculosis until either a cure has been effected, or it is distinctly settled that it alone is inadequate. Even when some further procedure is to be resorted to, fixation must be continued as an essential adjuvant.

Aspiration. If the disease assumes the hydropic form, aspiration is the simplest operation which can be resorted to. It relieves tension and promotes absorption. Compression of the joint by strapping with adhesive plaster, or by enveloping it with cotton and applying a firm bandage, will tend to inhibit the reaccumulation of fluid.

Iodoformization. After aspiration it is often advisable to inject a 10 per cent emulsion of iodoform and glycerin into the joint. One treatment is rarely sufficient and it is almost certain that the fluid will reaccumulate. If aspiration and iodoformization, however, are repeated at intervals of a few weeks, the amount of fluid in the joint steadily diminishes, and a complete cure often results. A combination of immobilization, aspiration and iodoformization should always be faithfully tried before resorting to more heroic measures.

Operative Treatment. When the foregoing methods fail, we are left the choice of four operations, which are described in the order of their conservatism.

Arthrectomy consists in opening the joint and the removal of its synovial membrane, together with such part of its capsule and ligaments as are diseased. Although as a result there is usually loss of motion, the limb is not much shortened and is very useful. Unfortunately the range of usefulness of this operation is limited. It is applicable only in the primary synovial form of the disease, because if the disease begins in bone or has extended to it, it will not remove all of the infected tissue.

An atypical resection consists in opening the joint, the removal of the diseased synovial membrane, capsule and ligaments, and curetting out any foci of disease in the articular ends of bone forming the joint. This operation is especially indicated in dealing with the disease in children, provided it is sufficiently radical to effect a cure, as it does not remove the epiphyseal extremity of the bone and thus impair the growth of the limb.

A typical resection consists in opening the joint and sawing off the articular ends of the bones, thus removing the joint. When the operation is done upon the hip or shoulder, the osteal surfaces are held apart so that fibrous union may result, giving the patient a false or flail joint; when it is done upon the knee, the osteal surfaces are held in close apposition by means of sutures, nails or splints, in order that ankylosis may follow and the patient may have a stiff leg. A typical resection should not be done on children if the disease can be removed by more conservative measures, because the destruction of the epiphyseal line will arrest or retard the growth of the limb, so that at maturity it may be useless if not burdensome.

An amputation or the removal of the limb joint in tuberculosis is usually the result of ignorance, neglect or delay on the part of the patient or his physician. Still, it is often the only means of saving life, when the disease has been allowed to go from bad to worse until a tuberculous disease has perforated the capsule, and infiltrated the adjacent tissues.

LECTURE XXXIII.

SYPHILIS.

Definition. Syphilis, pox, or lues venerea, is a constitutional disease due to a specific germ, and is characterized by the formation of a primary lesion at the point of inoculation, followed later by the constitutional manifestations of systemic infection.

History. The history of the disease is of great interest. Many of the old records of what was called leprosy have been proved to be cases of syphilis, and a more careful and accurate reading of the ancient scrolls and manuscripts has shown that the disease existed in malignant form among the Egyptians and Chinese 2000 years B. C. Hence, as far as antiquity goes, the disease is very respectable.

The first classic description of syphilis appeared in the latter part of the fifteenth century, shortly after the discovery of America. About this time there was a widespread epidemic of the disease in Europe. It was claimed by writers of that period that syphilis was indigenous among the Indians and had been brought to Europe by sailors who had been infected in America. The disease at this time was of a malignant type characterized by extensive ulcerative lesions and in most cases by speedy death. Owing to the lax morality then existing at Court and among the peasantry, it became rapidly disseminated.. It is a historic fact that in 1494 Charles VIII of France had to abandon his campaign in Italy because over one-half of his soldiers contracted syphilis.

The disease was shortly implanted by the white man into Africa, and its malignant progress among the native negroes caused frightful mortality.

Until the day of John Hunter, no distinction was made between the three diseases—gonorrhea, chancroid and syphilis—but they were thought to be only different manifestations of the same trouble. Hunter, the close observer and great surgical philosopher, noted the difference between gonorrhea and syphilis, and declared one to be local, and the other a systemic infection. His views were ridiculed, and in order to demonstrate them he inoculated his own arm with pus from a gonorrhea patient. Unfortunately for John Hunter, and unfortunately for science, the man from whom the pus was obtained had syphilis as well as gonorrhea and as a result Hunter developed syphilis from which he ultimately died. Needless to say after this apparently conclusive proof of his mistake he abandoned his position.

Fifty years later, Ricord again took up the question and demonstrated the difference between gonorrhea and syphilis. In comparatively recent times, Bossereau showed that chancroid was a distinct disease. The last named investigator said that there was one kind of chancre which was only local in its effects, and another kind which produced constitutional disease. The first he called soft chancre (chancroid); the second hard chancre (syphilis). The terms soft and hard chancre were unfortunate, as they apparently indicated some relation between the two conditions. It is now recognized that they are separate diseases, and are called by the distinctive names, chancroid and syphilis.

Attenuation. Syphilis as it existed in the fifteenth century was a very malignant and fatal disease. It has, however, become attenuated; and now under proper treatment has lost much of its virulency. This is due to better hygienic conditions, to more rational therapeutics, and to the fact that the entire population is more or less protected by an inherited immunity. It is stated by conservative and reliable authorities that one out of every twenty people in the United States has had syphilis. Lydston says that in Chicago one out of five would not be far from the truth. This being the case, we all have to a certain extent a resistance to the disease due to its existence in one of our remote or immediate ancestors. However unpleasant this theory may be, it is rendered plausible by the history of other infectious diseases. Measles was unknown in the Sandwich Islands until introduced by the missionaries. The disease ran a mild course when it affected the whites, but it was very malignant when it attacked the natives. In fact, it caused the death of more than two-thirds of the entire population. The only explanation is that the first class were protected by hereditary influences while the second were not so protected.

Mortality. Syphilis rarely itself proves fatal. Most of the deaths among syphilitics are not due to the disease but to the results of the disease. Crippling sequelæ of the secondary and tertiary stages are in inverse ratio to the thoroughness of the treatment. Syphilis impairs the vitality of its victims so that they frequently become the prey of intercurrent tuberculosis. The nature of the end results of a badly managed case of syphilis is indicated by an enumeration of the terms aneurism, arteriosclerosis, cirrhosis of the liver, general paresis, and locomotor ataxia.

Cause. For many years syphilis has been supposed to be caused by a germ. This was due to the analogy seen to exist between it and other recognized microbic diseases. It was contagious and could be transmitted from a diseased to a healthy individual; it had a definite period of incubation, and symptoms did not develop after exposure until the lapse of a certain time; it was characterized by an eruption similar to measles and other acute exanthemata; it was attended by a peculiar set of sequelæ; and finally one attack usually conferred immunity to the individual. Many investigators have claimed to have discovered the specific cause, but until the publication of a description of the spirocheta pallida by Schandinn and Hoffman in April, 1905, these claims have been unsubstantiated. While the four laws of Koch have not yet been fully fulfilled by this new organism, yet it is confidently believed that it is the essential cause of the disease. The spirocheta pallida is from four to ten micromillimeters in length and varies from unmeasurable thinness to 0.5 micro-millimeters in width. It has from three to twelve sharp and regular curves which resemble the outline of a corkscrew. The organism has flagella and is capable of motion. The spirocheta pallida is very refractory to stains and being scant in the lesions it is hard to find. By the use of Goldhorn's stain it is colored a purple which may be changed to a dark brown by treating the specimen with Gram's or Lugol's solution. The spirocheta pallida has been found in the chancre and the adjacent lymph nodes of the primary stage, and in mucous patches, skin lesions, and occasionally in the circulating blood of the secondary stage. It is not often found in lesions of the tertiary stage, nor has it ever been demonstrated in non-syphilitic sores. As previously indicated more stringent proof will have to be produced in the future to absolutely establish the status of this organism.

Pathology. The pathology of syphilis can best be described by taking up some of the most important of the various lesions which characterize the three stages of the disease.

1. *The Chancre,* or original lesion, makes its appearance at the seat of inoculation. At first it is either a red or somewhat inflamed papule, or a vesicle which undergoes rupture and ulceration. The peculiar feature of a chancre is its hardness or induration. It may soon heal leaving a more or less definite scab, or it may for a long time remain indolent as a small erosion. Histologically the chancre first presents small areas of round cell infiltration in the neighborhood of the blood vessels of the deeper layers of the skin or mucous membrane. Later the connective tissue element of the part undergoes proliferative changes and spindle cells are mingled with the round cells. Finally a thickening occurs of the coats of the blood vessels and lymphatic vessels often causing their obliteration. The induration is due to the sclerosis of the vessels and the general connective tissue hyperplasia. The spirocheta pallida is found in the lesion.

2. *Skin lesions,* in the form of papular, macular and scaly eruptions, are an early and prominent symptom of the secondary stage. The essential histologic changes which enter into the formation of a syphilitic papule are hypertrophy of the papillæ of the skin, increase in the number of epithelial layers which form the epidermis, and a proliferation of the cells of the rete mucosa. The blood vessels are engorged and an extravasation of the blood elements occurs into the tissues of the derma, giving in white people the characteristic coppery color of the lesion. Desquamation of the superficial layers of the skin occurs from lack of proper nutrition.

3. *Mucous patches*, or condylomata lata, are another lesion of the secondary stage. They appear as a somewhat elevated patch with a superficial erosion or ulceration. The surface has a necrotic appearance and may be covered with more or less secretion. The histologic changes found in a mucous patch are similar to those of the initial lesion or chancre. There is round cell infiltration of the deeper layers of the mucosa and proliferation of the connective tissues. There is sclerosis of the blood and lymphatic vessels. Later there is exudation of serum and erosion of the surface. The papillæ become considerably elongated, swollen and richly infiltrated with small cells. The epithelial cells enlarge, their nuclei become fragmented and proliferated changes take place giving rise to the appearance of small cell nests. In nearly all secondary lesions the spirocheta pallida has been found.

4. *Syphilitic Gummata.* The lesions of the tertiary stages of syphilis consist in diffuse changes, the most conspicuous of which are the atheroma of the intima of the blood vessels, certain alterations in the liver, spleen, kidneys and heart, and fibroid overgrowths or thickening causing injury to the central and peripheral nervous system. These changes are due to hyperplasia of the connective tissue and can not be distinguished by their microscopic or general features from sclerosis due to other causes. The localized lesions of the tertiary stage are gummata, which are nodular masses varying in size from a minute tubercle-like formation to tumors the size of an orange. They are seen most frequently in the bones (tibia, sternum and skull) and in the internal organs, such as the liver, lungs, kidneys, heart and brain. They are hard and frequently have an elastic consistency which has suggested the name gummy tumors or gummata. On section the substance is frequently found to be gelatinous or mucoid in appearance; but there is nearly always considerable induration. Occasionally, gummata soften rapidly and become converted more or less completely into puriform collections. When situated in the mucous membranes or adjacent to the surface of the body, suppurative, fatty or necrotic softening may lead to the formation of superficial ulcerations. These may remain indolent or grad-

ually become cicatrized. Sometimes a gummatous lesion disappears by absorption without leaving a trace of its existence. The gumma is composed microscopically in large part of round cells derived from the blood, and of spindle cells, the result of the proliferation of connective tissues. Epithelioid cells are present but less abundant, and giant cells—though occurring at time—are usually few in number. The blood vessels are nearly always more or less affected, the intima particularly being thickened. There is also new formation of blood vessels, the lesion in this respect differing from the nodular lesions of tuberculosis. Secondary changes are always seen in gummata of considerable dimensions. Among these may be recognized a gradual necrotic transformation of the cells in the center of the lesion, with distinct fatty degeneration or myxomatous change. The reputed germ of syphilis is rarely found in tertiary lesions.

Methods of Contagion. Syphilis may be either hereditary or acquired. Hereditary syphilis is due to one or both parents having the disease and transmitting it to the child. This form will be discussed later. Acquired syphilis is inoculation after birth. It is impossible for infection to occur through the unbroken skin or mucous membrane. It must be remembered, however, that the solution of continuity in any given case may be so slight as to escape observation and may not be demonstrable even by means of a magnifying glass. Moreover by the time of the appearance of the chancre such lesions may be entirely healed. Finally it must be remembered that on the genitalia and other parts continuously subjected to the influence of moisture and heat the epithelial covering may be so attenuated, macerated and exfoliated as to be readily inoculated even in the absence of actual fissures or abrasions.

For a long time it was thought that every product emanating from an infected person, such as tears, sweat, saliva and even the breath was capable of transmitting syphilis. It is now known that the disease is transmissible only through the products of the primary and secondary lesions and the circulating blood. The presence of the spirocheta pallida in only these lesions, and in the blood in only these stages strengthens the belief of its specific relation to the disease.

The physiologic secretions from the special glands, such as the salivary, milk and sweat glands, the normal kidney and testicle, unless contaminated by admixture with a discharge from a primary or secondary lesion, or by blood or lymph, will not convey the disease even during the most active stages. This is easily accounted for when it is borne in mind that the special products from these glands are the result of elaboration within their epithelial elements, and that these cells select from the blood the proximate principles necessary for their work. The essential cause of syphilis does not penetrate intact epithelium.

Spermatozoa and ova are not products of secretion, but active, living, organic structures. Each of these elements is capable therefore of grafting the disease on the other.

A person may become inoculated with syphilis in one of two ways, by immediate or direct infection, and by mediate or indirect infection. By the first is meant that the contagion is conveyed by contact from one individual to another without a medium of transmission; by the second is meant that the contagion is conveyed from an infected to a non-infected individual, not by contact, but by means of a medium or "go between."

Immediate or Direct Infection. By far the most frequent method of direct infection is through sexual intercourse, the site of implantation being on the genitalia. The next most common method of transmission is through labial contact incident to the custom of indiscriminate kissing. The finger of the gynecologist, obstetrician, or nurse is often inoculated through contact of an abraded or fissured point with primary or secondary lesions or bleeding areas, and surgeons and dentists have been repeatedly infected by contact of blood from a patient in the secondary stage of syphilis upon such unprotected lesions as hang nails, fissures and incised wounds present either before or inflicted during the course of an operation. The converse is equally true. The victim of primary or secondary syphilis should therefore not practice surgery, dentistry or midwifery.

In at least one case (White and Martin) the site of inoculation was a punctured wound on the skin of the lower eyelid through which a man having mucous patches in his mouth removed by mouth suction a blood clot caused by traumatism to this region of his comrade's face. The blood of an individual with secondary syphilis is equally liable to cause chancre in some part of the mouth of a non-infected individual. Sexual perverts have repeatedly conveyed and contracted the disease while engaged in their pernicious practices. Teeth bites inflicted by syphilitics prepare the site for inoculation by the abrasion produced, and at the same time the infective agent may be transmitted by the inoculated buccal fluids.

Sucking infants are not uncommonly the victims of primary lesions in their mouths acquired from a chancre, secondary lesion or fissure on or about the nipple of a syphilitic wet nurse. On the other hand an infant with mouth syphilis may inoculate the disease upon the nipple of a non-infected woman.

Mediate or Indirect Contagion. The media of contagion include water-closet seats, drinking vessels, spoons, pipes, cigars, razors, surgical and dental instruments, catheters, towels, sponges, dressings, handkerchiefs, articles of clothing, and other material used upon a syphilitic. During the period when humanized vaccine virus was used syphilis was not infrequently transmitted by the employment of a scab containing the dried blood of an individual suffering from the secondary stage of the disease. The process of tattooing has been a means of transmission. Melot reports a case in which a nasal chancre developed upon an individual three weeks after being struck on the nose by the whip-lash of a teamster. The latter was in the habit of biting his lash and was found to be the victim of mucous patches in his mouth. The "styptic pencil" used by barbers was believed to be the media of transmission in at least one case reported by Patterson. Many chancres on the tongue have been attributed to the dirty habit of wetting the point of a lead pencil on this organ. Mid-wives have conveyed this disease from one woman to another without contracting it. At least one case is reported in which the infective agent was carried beneath a redundant prepuce from one woman to another and the man entirely escaped. On the other hand a married woman is believed to have conveyed the exciting cause of the disease by way of her vagina from an infected lover to her husband without herself becoming infected. A young physician developed a typical chancre on his nose three weeks after attending a syphilitic woman in labor. (Hirst.) There was no abrasion on his hand but there was a slight nasal fissure. He rubbed his nose before thoroughly washing the infected agent from his hand. Many illustrations of such accidental disasters could be cited.

Immunity Against Syphilis. The disease has for its habitat the human race, though it may be inoculated into the higher apes, and in an atypical form into lower monkeys.

Immunity, like infection, may be acquired or inherited. Acquired immunity is limited to (1) those who have suffered a previous attack of the disease; (2) the mother who has borne a syphilitic child without herself showing any lesions of acquired syphilis (Colle's immunity); (3) the child who escapes inherited syphilis from its infected parents (Profeta's immunity). The offspring of parents who have suffered the actute disease or who have inherited immunity are sometimes completely immune, and generally partially so.

Immunity conferred by acquired syphilis against fresh infection is present from the earliest stages of the disease, persists long after all syphilitic manifestations have disappeared, and such immunity may even be transmitted to offspring.

Although syphilitic re-infection is exceedingly rare it undoubtedly has occurred. Most cases of so-called re-infection are due to errors of diagnosis either in regard to the first or second attack. There is an indurated tertiary skin lesion called "pseudo chancre," which bears some resemblance to the primary lesion or true chancre and this may account for some reported cases of second infection. There is no authentic case of re-infection in a patient showing the signs of secondary syphilis; and re-inoculation practiced upon individuals presenting tertiary lesions have been uniformly unsuccessful.

Profeta's immunity, namely, that observed in the offspring of syphilitic parents; and Colle's immunity, in accordance with which the mother of a child syphilitic by its father cannot be inoculated with the disease, are both dependent on absorption of antitoxins through the placental circulation into the blood of the child on the one hand (Profeta's immunity), or into the maternal blood on the other (Colle's immunity), or upon the fact that the mother or child as the case may be, has really been the victim of the disease in latent form or so attenuated in virulence as to be incapable of producing lesions. Such is the immunity to smallpox conferred by vaccination.

Partial immunity, due to the hereditary transmission of an attenuated specific poison has rendered the disease decidedly less malignant in its victims of the present day than of former generations.

LECTURE XXXIV.

SYMPTOMS OF SYPHILIS—PEN PICTURE OF A TYPICAL UNTREATED CASE—DETAILED DESCRIPTION OF LESIONS OF PRIMARY, SECONDARY AND TERTIARY STAGES.

The *symptoms* of acquired syphilis are divided, for study, into three stages—primary, secondary and tertiary. Each stage has a period of incubation, which precedes the development of its characteristic features.

These symptoms are so numerous in form and distributed over such a lengthy period of time that it is well for the student to get a general view of the picture before he takes them up in detail. The following is, therefore, given as an outline of the characteristics of a typical untreated case of syphilis.

A man has connection with an infected woman and during the act abrades his penis. On going home his attention is attracted to the injury and he washes and disinfects it. For a day or two he is extremely anxious, but as the wound promptly heals he soon forgets it. In about three weeks he accidentally discovers a small, hard lump at the site of inoculation, which slowly increases in size. It gives no pain, but a guilty conscience makes him watch it constantly. In a few days he notices that the lymph nodes in both groins begin to enlarge, until finally the whole chain is affected. They are hard, painless and freely movable. For six weeks after he discovered the initial lesion, which was followed by the formation of bubo, no other symptom develops. Then he begins to feel bad; he has headache, backache, has a little fever, and thinks he has contracted a cold. One morning on getting out of bed he finds he is covered with an eruption which resembles measles, the discoloration being symmetrically distributed over the body and unattended by itching. In a day or two his throat gets sore and his voice becomes hoarse. Later sores, called mucous patches, form on his tonsils, his tongue, and on the inner side of his cheeks. His eyes become red, inflamed and sensitive to light. Still later, he begins to lose hair, which is not limited to his scalp, but occurs, also from his eyebrows, eyelashes, axillæ and pubes.

The symptoms above described finally get better, and again there is a resting stage, which after a variable period of time, is followed by another train of events. Hard nodules appear beneath the skin at various portions of the body, which gradually approach the surface, break down and form open granulating sores. Gummata form in the bones and in the various viscera, causing pain and functional trouble. Finally, and most disastrously, deposits occur in the brain and spinal cord, producing by pressure or ulceration serious and often fatal nervous disorders, such as locomotor ataxia, paralysis and paresis.

We will now take up the different symptoms, as they appear in the different stages, and study them more minutely.

PRIMARY SYPHILIS.

1. *The Period of Primary Incubation.* This is the time which intervenes between the infection of the individual and the appearance of the first evidence of the disease. It varies from ten days to three months, the average time being about three weeks. During this time there are no local or general symptoms, and the individual is in ignorance of his condition.

2. *The Period of Primary Symptoms.* At the expiration of the period of primary incubation there are the development of the primary symptoms, which consist of the chancre and bubo.

Chancre. A chancre is called the primary lesion of syphilis and invariably occurs at the point of inoculation. As the disease is usually contracted through sexual intercourse, the chancre is usually located on the penis in the male and on the labia in the female. If it is contracted by kissing, it is located on the lips or tongue, and if it is contracted by surgical work, it is located on the fingers or hand. A chancre begins as a macula or spot of discoloration. It soon thickens and becomes a papule. It gradually extends in circumference and depth and becomes markedly indurated. When uncomplicated, it is usually painless. A chancre is almost invariably single, although rarely more than one sore may be observed. This is not due to auto-inoculation, due to the fact that the patient was infected in more than one place at the same time. Often there is no solution of continuity of the skin covering the chancre; but again ulceration may occur and a cup-shaped depression result with sloping margins and a foul floor. Induration is the most characteristic feature of a chancre and is due to a sclerosis of the lymphatic vessels of the skin. There are two horizontal sets of vessels in the skin, one just beneath the surface and the other at the base of the derm. If the upper set are involved, then the induration is superficial; if the lower set are also invaded then the induration is deep. Induration is best detected by pinching together the soft parts wide of the lesion until the hardened edges are felt by the thumb and finger placed on opposite sides of the sore. The whole plaque is then lifted from the subcutaneous tissue, when, by further gentle palpation, the depth and extent of the induration can be determined. To protect the examiner from inoculation palpation may be practiced through a layer of gauze or other soft material. The induration of chancre is so characteristic that when it has once been felt it cannot be easily mistaken for anything else. In all inflammatory processes there is some induration, but it shades off into adjacent tissue so gradually that it is hard to tell where it stops and where normal consistency begins. The induration of a chancre is different. Its boundary line is sharp, abrupt and well defined. It feels as if a foreign body were implanted in or beneath the skin. The surgeon, in palpating, will sometimes find a superficial induration, which, when grasped by its edges, will feel like a piece of parchment. Again, he will find a deep induration which will feel like a hard pea or small fragment of wood. Again he will find an annular induration, a form in which sclerosis involves only the margins of the chancre, leaving the center soft, causing the lesion to feel like a small ring. A chancre commonly heals in from four to six weeks. If induration has been only superficial it may completely disappear in this time. If it has been deep or nodular in character, however, it may persist for months or years. Occasionally, induration completely disappears from the site of inoculation, and after months becomes again noticeable, and this constitutes a form of the so-called "pseudo-chancre."

Certain complications may occur with chancres causing them to assume different appearances and take different clinical courses.

Simple Inflammation. From mechanical injury, or secondary infection, a chancre may become inflamed, and as a result there will develop pain, heat, redness, swelling and purulent discharge.

Chancroidal Inflammation. The organisms of chancroid and syphilis may be inoculated at the same time. In this case the chancroid will appear first and may even heal before the characteristic induration of chancre is noted. Most frequently, however, the chancroid persists and the spreading inflamed and freely discharging ulcer, with its punched-out margins, gradually becomes developed into a typical syphilitic lesion.

Secondary inoculation of chancroid on a well-developed chancre may occur in an individual who continues promiscuous sexual indulgence after the original infection. In this case the whole area of induration may slough away, leaving no sign of chancre. Finally the organism of syphilis may be inoculated upon a chancroid; the latter is unaltered except for the added induration. A sore resulting from the inoculation of both syphilis and chancroid at the same spot is called a mixed chancre.

Papillary Outgrowth and Conversion of a Chancre into a Mucous Patch. Associated with chancre there is often an abundant outgrowth of warts, due to the local irritation of the part. During the secondary stage of syphilis, if the chancre has not healed, it may become covered with gray false membrane and present all the characteristics of a mucous patch.

Phagedena and Gangrene. Phagedena is caused by inflammation more rapid and intense than that which characterizes an inflamed chancre. There is death of tissue and sloughing. Some times phagedena progresses slowly and in a serpiginous fashion. Phagedena is more liable to occur in individuals of feeble constitutions, yet it is noted at times in the robust. There is undoubtedly a constitutional predisposition to phagedena, although it is a fact that in the same person one sore may become phagedenic while others remain uncomplicated.

Vaccination Chancre. With the use of the modern bovine virus there is no danger of chancre following vaccination. In the old days, however, when human lymph was employed, the production of vaccination syphilis was not infrequent. In some cases the vaccine pustule healed before evidence of chancre appeared. In other cases, the sore refused to heal, presented a smooth surface and scanty discharge, until finally the characteristic induration of chancre developed.

Leaving the subject of chancre, we next take up the second of the two lesions of the primary stage—namely, the bubo.

Syphilitic Bubo. Within about a week after the appearance of the chancre the nearest lymph nodes undergo a painless enlargement. If the chancre is upon the genital organs, the nodes enlarged will be in the groins; if the chancre is located on the lip, the nodes enlarged will be the submaxillary; if the chancre is upon the finger, the nodes enlarged will be the epi-trochlear; if the chancre is upon the nipples, the nodes enlarged will be the axillary. In genital chancre the hypertrophy commonly takes place in both groins, although rarely it is limited to one side. The nodes are each distinct—hard, almond-shaped, painless and freely movable. As a rule the whole group of nodes are ultimately involved; occasionally, however, but a single one is affected. Suppuration never occurs unless there is secondary infection with pyogenic organisms.

SECONDARY SYPHILIS.

Period of Secondary Incubation. The chancre of the primary stage may have healed, the buboes give no pain or discomfort, and the patient begins to think, owing to the failure of other symptoms to develop, that there must be some mistake in the diagnosis of syphilis. His hopes are soon shattered, however, for he is but passing through a second period of incubation, which is to be followed by the development of marked, unmistakable and conclusive secondary symptoms. Usually this second period of incubation, or time which elapses from the development of the chancre until the appearance of the sore throat, eruption and other secondary symptoms, is about six weeks.

The Period of Secondary Symptoms. This period is characterized by (1) alteration of blood; (2) general lymphatic enlargement; (3) moderate fever; (4) muscular and articular pains; (5) alopecia of the entire body; (6) eruptions of the skin and mucous membrane.

Alteration of the Blood. The blood changes are the first signs of constitutional syphilis, antedating lymphatic involvement by two or three weeks. There is a diminution in hemaglobin and number of red corpuscles with slight leucocytosis. These signs become more marked with the advent of fever and the appearance of skin eruptions.

General Lymphatic Involvement. About the sixth week after the appearance of the chancre there slowly develops an enlargement of all the lymph nodes of the body. This is especially apparent where the nodes are accessible to palpation, such as the epi-trochlear and the post-cervical regions. The hypertrophied nodes vary in size from that of a pea to that of a chestnut and are hard, painless and freely movable. Although there is no clearly established relation between the extent of lymphatic involvement and the severity of the other secondary symptoms, marked involvement of these structures has usually been noted in bad cases.

Syphilitic Fever. About the time of lymphatic enlargement, and preceding or coincident with the earliest skin eruptions, there is the development of moderate fever. In some patients this symptom is not noted; in others, it assumes marked prominence. Usually the fever is continuous, but sometimes of an intermittent type. It commonly disappears with the development of the eruption.

Syphilitic Pain. During the existence of fever the patient often suffers a variable degree of pain. It is commonly neuralgic and shifting in character, and is most marked about the neck, shoulders and back. It occasionally attacks one or more joints. It is always worse at night.

Syphilitic Eruptions of the Skin. Syphilides, or skin eruptions, commonly appear a short time after the general lymphatic involvement. They are usually noticed about six weeks after the formation of the chancre. Rarely they have appeared within two weeks, or have been delayed as long as four or five months. The characteristic features of secondary syphilitic eruptions are (1) that they are protean; (2) that they are symmetrically distributed; (3) that when they begin to fade they leave a peculiar red coppery discoloration; and, (4) that they do not itch. By being protean in type is meant that the eruption is not strictly a macular, or papular, or vesicular, or pustular eruption, but is polymorphous—in other words, consists of a mixture of two or more varieties. By being symmetrically distributed is meant that if the eruption is found on one arm it is found on the other; if upon one side of the chest it will also be on the other; if one leg is broken out the other will be similarly involved.

As the eruption develops pigmentation occurs. When it begins to fade it leaves a dark copper colored stain resembling raw ham. Most syphilides tend to become squamous as a result of interference with nutrition. If the eruption is of a dry type the skin is scaly, and if of the ulcerative type chronic sores form covered with thick greenish-black adherent crusts. Itching, which is characteristic of so many other eruptions, is absent, as a rule, in syphilides. If itching is present, it is due to complications, such as urticaria, prurigo or pediculosis. In syphilitic eruptions the influence of mercurial treatment is rapidly seen, and is a final test of the correctness of the diagnosis.

Syphilitic Eruptions of the Mucous Membrane. Involvement of the mucous membrane is one of the most constant symptoms of secondary syphilis. It often appears before the skin eruptions. It may be in the form of an acute erythema, unaccompanied by marked edema. The transformation of a syphilitic papule into a mucous patch takes place whenever the papule is so placed as to be under the continuous influence of warmth, moisture and friction. These conditions are specially met with at the mucocutaneous juncture, and in the creases of the folds of the skin or mucous membrane. Mucous patches appear as grayish-white irregularly-shaped, non-elevated markings. The appearance of a mucous patch is similar to that produced by the application of a stick of silver nitrate, except that the margins of the mucous patch are more sharply defined. The lesion is moist and covered with an offensive exudate and is highly contagious. The common seats of mucous patches are the mouth, the genital organs and the region of the anus. In women mucous patches are specially common on the vulva and labia, and are also seen beneath a dependent mammary gland. In men they are not frequently met with on the prepuce or glans penis, the most common seat being the folds of the scrotum; occasionally one is found in the urethra, giving rise to a discharge, which resembles gonorrhea.

Syphilitic Alopecia. The impaired nutrition of hair follicles, secondary to syphilitic lesions of the skin, causes the hair to lose its luster and to fall out in regular patches. Usually the scalp and eyebrows are chiefly affected; sometimes all hairy regions are involved. Rapid onset, irregular distribution and the curative effect of constitutional treatment are the characteristic features of syphilitic baldness.

Affections of the Eye and Ear. Conjunctivitis and iritis are frequent symptoms of secondary syphilis. They present no clinical characteristic, except a tendency to throw out lymph. Both eyes are often attacked, but not simultaneously. Retinitis and choroiditis are sometimes seen. Acute inflammation of the membrana tympani sometimes occurs and may cause permanent deafness.

TERTIARY SYPHILIS.

The Period of Tertiary Incubation. The secondary stage of syphilis lasts from one to three years. Then there is a period in which there are no symptoms, or so slight and irregular as to lead the patient, and sometimes the physician, to believe the disease has been eradicated. This is the period of tertiary incubation and lasts from two to four years. It may end in complete recovery or be followed by tertiary lesions.

The Period of Tertiary Syphilis. In the majority of properly treated cases the lesions of this period never occur. When the disease is not properly treated, tertiary signs become apparent, generally in the third or fourth year. Clinically, the features of tertiary syphilis are due to the deposit in various parts of the body of a new material, which may take the form of a contractile lymph, leaving depressed cicatrices, or of soft, gummy substance constituting the so-called gummatous syphilitic tumors. In the tertiary stage the spirocheta pallida cannot be found in the blood or lesion, and the disease is non-contagious and cannot be transmitted to the offspring. Tertiary syphilis may affect any tissue or organ of the body and the symptoms of this stage are developed so irregularly that it is impossible to classify them chronologically. We will, therefore, consider them under arbitrary heads.

Skin. The cutaneous symptoms consist of tubercular and squamous eruptions, together with a destructive form of rupia. Gummatous masses form in the skin of the forehead, arms, legs and chest. At first they are round, subcutaneous nodules, which may either slowly grow, soften and break down, or they may not ulcerate, but become dry and hard and form a syphilitic tubercle. Onychia and ulceration of the matrix of the nail, causing it to be distorted or destroyed, is also frequently seen.

Mucous Membrane. The tongue is often affected, either being the seat of ulceration or having a deep deposit, causing stiffness and the contraction or distortion of the organ. The tonsils, fauces and palate suffer from ulceration, which frequently causes difficulty in swallowing or regurgitation of fluid through the nostrils. The larynx and trachea may be affected by syphilitic deposit which changes the voice or interferes with respiration. The pharynx, and frequently the esophagus, is often the seat of infiltration, which may result in stricture.

Solid Viscera. Syphilitic deposits may occur in the testicle, liver, spleen, kidneys, lungs and heart, causing interference with their various functions.

Nervous System. The brain and spinal cord are often the seat of deposits causing disturbances manifested by epilepsy, paralysis, chorea, mental perturbation, dementia, locomotor ataxia, etc.

Arteries. The inner coats of blood vessels may undergo sclerosis so as to seriously interfere with their lumen. The large vessels alone are affected, thus differing from the changes incident to age.

Bones and Periosteum. Periostitis is of frequent occurrence. It is usually circumscribed and gives rise to the formation of oblong swellings called nodes. Chronic arthritis with caries and necrosis are also seen. This may affect any bone, but is more frequent in the jaws and skull.

LECTURE XXXV.

HEREDITARY SYPHILIS—THE DIAGNOSIS AND PROGNOSIS OF THE DISEASE—SYPHILIS AND MARRIAGE.

Hereditary syphilis, or syphilis of a child due to disease of one or both parents, is characterized by having no primary stage. The disease is conveyed directly to the circulation of the embryo without local inoculation, and, therefore, there is no chancre or bubo. The term infantile syphilis is sometimes used, but this is inaccurate, as an infant may acquire syphilis as well as inherit it. A child may become inoculated with syphilis by being kissed by an infected individual, or may acquire it from a syphilitic wet nurse.

The cause of hereditary syphilis is the presence of the active disease in one or both parents at the time of conception, or in case of maternal infection, during the first eight months of pregnancy. It is stated that hereditary syphilis may result under four different conditions: (1) the mother being syphilitic, the father being healthy; (2) the mother and father both being syphilitic; (3) the mother acquiring syphilis after impregnation; and, (4) the father transmitting the disease to the child without infecting the mother.

If the mother is syphilitic and the father healthy the child may escape infection in utero and be born with immunity to the disease (Profeta's law). Again, it may be born with a manifestation of secondary lesions. When the father and mother are both syphilitic, the disease is usually transmitted in a malignant type and the child rarely survives. When the mother contracts syphilis after conception the result will depend on the progress which gestation has made. If it is in the early months of pregnancy, the disease is usually of a severe type, since the nutrition of the child is affected not only by the disease, but by the impaired nutrition of the mother. When the woman contracts syphilis after the eighth month of gestation the child usually escapes. When the father has syphilis, he usually transmits the disease to both mother and fetus, but in rare cases the mother fails to manifest signs of syphilis, giving birth to a syphilitic child and being subsequently immune to infection (Colle's law).

While it is generally true that virulent syphilis in the parents is most apt to result in a corresponding type in the child, and vice versa, yet to predict the type in the child upon the basis of that in the parent, is impossible. Parents with a mild type of the disease may beget an offspring with its most malignant form, and on the other hand parents suffering with virulent syphilis may beget offspring but slightly affected or absolutely healthy. Parents in the first year of syphilis are more apt to beget a syphilitic child than those in the later stages. In the tertiary period the disease is not contagious, and not likely to be transmitted. When the parents are properly and vigorously treated the danger of the transmission of syphilis may be practically disregarded after the fourth year.

Results to the Child of Syphilitic Parents. Abortion, or premature birth is the rule. It is the exception when a woman in the active stage of syphilis carries the child to term. Usually an abortion occurs about the third month. If a woman is an habitual aborter, and there is no other assignable cause, she should be put upon syphilitic treatment. It will do no harm and may do a great deal of good.

Birth at full term with well-marked secondary lesion. Abortion may not occur and the woman go to full term, and the child be born in the full bloom and blossom of syphilis.

The child may be born apparently healthy and develop the disease. Usually the lesions will be manifest in two or three weeks, but they may be delayed for two or three months. If syphilis does not develop within twelve months the child may be considered out of danger. If the disease develops after a year's time the child either had the symptoms earlier and they were overlooked, or else the child has contracted the disease since birth by one of the numerous dangers to which babies are exposed.

Symptoms. As stated, hereditary syphilis has no primary stage and there is the absence of the chancre and bubo. The secondary and tertiary lesions correspond closely with those of the disease as acquired after birth; the main point of difference lies in the profound alteration in nutrition. The typical syphilitic child at birth is a wasted, wizened, snuffling, feeble creature, with a weak, hoarse cry, and has aptly been compared to "a little old man with a cold in his head." The eyes are preternaturally bright and wise looking. The skin is harsh, non-elastic, gray or dirty yellow in color, and frequently the seat of bullous eruptions. The eye-lashes, eye-brows, hair, and nails show imperfect or perverted development. The muscles are wasted. There are mucous patches in the mouth and between the folds of the skin. The throat is sore, the nose occluded from a swelling of the mucosa, and nursing is difficult.

Following the first outbreak, there is an intermediary period, with few or no symptoms, lasting eighteen months or until second dentition. Physical development is retarded and the face remains wizened. The local signs of the disease include the flat or sunken nose, irregular prominence on the skull, ulceration of the palate, radiating cicatrices at the angles of the mouth, periosteal nodes, indolent ulcers, interstitial keratitis, sudden deafness without suppuration, and finally the characteristic Hutchinson teeth. These are the central incisors of the second or permanent set, which are deformed so as to be wedge-shaped, projecting forward with a notched cutting edge.

The diagnosis of late hereditary syphilis is generally difficult and often impossible without the therapeutic test—namely, the effect of mercury or iodide of potash, or of these remedies combined. The treatment of hereditary syphilis is practically the same as the treatment of the acquired form.

The Diagnosis of Syphilis. The question of whether or not a patient has syphilis imposes a great responsibility on the doctor, for not only is the health or life of the individual dependent upon the correctness of his conclusions, but that of many other innocent people as well. Lydston relates a case of where a young married man contracted syphilis and infected his wife; later a syphilitic child was born, from whom its grandmother and one aunt contracted chancre of the mouth: the grandmother ultimately infected the grandfather. It was not until five innocent people had been inoculated that the diagnosis was made.

While it is easy to recognize the disease when the patient is under observation from the time it is acquired until the manifestation of unmistakable secondary lesions, instances are frequently met with where a positive diagnosis is extremely difficult. This is due to the fact that the symptoms of the disease are often spread over a long period of time, and the patient has either forgotten important facts, or for obvious reasons his testimony is untrustworthy. The old gentleman will forget a little sore he once had, and never attribute the symptoms of his wife and children to those dimly remembered and lightly-weighed wild oats he sowed when a boy.

The moral character and general reputation of the individual should not be taken into consideration. A surgeon is not justified in prescribing specific treatment for a man merely because he has a suspicious sore, owing to the fact that he has led an immoral life, and, again, he should not hesitate to write mercury for a man who is apparently as virtuous as Joseph or as wise as Penelope, if the individual has the characteristic eruption, mucous patches, and other lesions of the disease. Frequently valuable aid in diagnosis may be secured by confrontation, or examination of the individual from whom the disease was contracted, its value being due to the fact that a chancroid can only produce a chancroid, while chancre can only result from chancre. Another means is by inoculation—that is, to take a secretion from a suspicious sore and inoculate it upon another part of the same individual's body. If it be chancroid, there will be reproduction of the sore; if it be a chancre, the result will be negative. Another method is by microscopic examination. Until recently this has been of little value, as there is nothing characteristic in the histologic structure of a section of a chancre. The future possibility of diagnosis by miscroscopic examination is most promising. Should it be absolutely established that the spirocheta pallida is the unquestioned cause, and should the technique of its demonstration become so simplified as to be practical to the clinician, we will have a certain test.

In the diagnosis of chancre it must be differentiated from chancroid, herpes, epithelioma, tuberculosis, inflamed sores, etc. The subject cannot be fully considered here. The following are the essential differences between a chancre and a chancroid: A chancre has a definite period of incubation, a chancroid has not; a chancre never develops under two or three weeks after exposure, a chancroid develops in from four to six days; a chancre is usually solitary, a chancroid is usually multiple; a chancre is not auto-inoculable, a chancroid is auto-inoculable—that is, will reproduce itself on the same individual. A chancre has a characteristic induration, a smooth surface and scanty secretion; a chancroid has little induration, a gray, sloughing surface, and furnishes a copious secretion. A chancre tends to heal spontaneously and is rarely phagedenic; a chancroid does not tend to heal, but to extend by the involvement of adjacent tissue. A chancre is attended by a bubo, composed of a number of nodes, which are hard, indolent, painless, and freely movable; a chancroid is not usually attended by bubo, but if the complication develops, usually only one node is involved, and it is painful, adherent, and tends to suppurate. A chancre is always followed by constitutional symptoms, whereas a chancroid is a local disease and never attended by systemic infection.

The diagnosis of typical secondary manifestations of syphilis is usually easy. The development of general lymphatic enlargement, moderate fever, and muscular and articular pains; the cutaneous and mucous eruptions unattended by itching or discomfort; the sore throat, mucous patches, iritis, and alopecia form a group of phenomena, which, occurring from five to seven weeks after a suspicious sore, are absolutely diagnostic. In certain cases, however, the picture is not plain, as the primary sore may have passed unnoticed or the secondary symptoms masked by the premature administration of mercury. Lymphatic nodes may hypertrophy from other causes than syphilis; fever may be due to grip or intercurrent disease; muscular and articular pain to rheumatism; skin eruptions may be due to measles, chicken-pox, or other acute exanthemata, and sores in the mouth may be ordinary stomatitis. A person with a form of hysteria, known as syphilophobia, or dread of syphilis, may give a history and present symptoms so closely analogous to the real disease as to puzzle the most experienced.

Tertiary syphilis is diagnosed by the history of the patient, which, as stated, is often vague and misleading, but more especially by the presence of cutaneous scars, periosteal nodes on the tibia, and enlargement of the post-cervical lymphatics, which in cleanly people are rarely hypertrophied from other causes than syphilis. Finally, it may be stated that in many cases the diagnosis of the disease must be based on the therapeutic test—that is, the result of the administration of mercury in the secondary stage and of iodide of potash in the tertiary stage.

The Prognosis of Syphilis. The prognosis of syphilis is good when proper treatment is instituted early and continued vigorously for a sufficient length of time. If taken in the early secondary stage, the disease can be positively and permanently cured. If neglected and allowed to progress to the tertiary stage, the disease can only be held in check. If as soon as the patient develops the first symptom upon which a positive diagnosis of syphilis can be based, he is put upon mercurial treatment, the evidences of the disease will all disappear in two or three weeks' time, and if the treatment is intelligently continued there will never be any further manifestation. A patient with syphilis is always a pleasant one to deal with, both professionally and financially, as he usually absolutely follows directions and promptly pays his bills. If, however, the disease is neglected and syphilis runs its course and is followed by its results—namely, tertiary lesions, then the case is hopeless, as far as a permanent cure is concerned. The symptoms will yield to iodine preparations, but will recur at unexpected times and in unusual forms. Among some of the most important tertiary manifestations are brain tumors, cerebral softening, apoplexy, insanity, locomotor ataxia, paralysis, embolism and thrombosis, cirrhosis and gummata of the liver, and nephritis. Stenosis of the various canals incident to contraction following gumma formation may be noted in the esophagus, rectum and larynx. Disabling deformity may result from bone lesions. Blindness and deafness are not uncommon.

Syphilis and Marriage. The frequency of syphilis makes the question of when one of its victims may safely marry a common and perplexing one to the physician. He must be the judge and jury and sometimes when his decision is not accepted will have the perplexing problem of whether or not he will let his pledge of professional secrecy permit him to see a woman, he perhaps knows personally, be led to the altar by a man whom he believes will almost certainly infect her. Some self-righteous authorities go so far as to say that no man who has ever had syphilis has a right to marry, but this dictum is unsubstantiated by the facts, and if accepted would inflict many hardships and materially diminish our prospective population. The majority of syphilographers agree that the most prudent and conservative practitioner may advise a man to marry four years after he contracted the disease, provided he has been intelligently and persistently treated; and, provided further, that for the last two of the four years no symptoms of the disease have manifested themselves.

LECTURE XXXVI.

TREATMENT OF SYPHILIS—LOCAL, SPECIFIC AND CONSTITUTIONAL.

The treatment of syphilis is divided for description into local treatment, specific treatment, and general treatment. It should be remembered, however, that while they are considered separately they are all frequently carried out on the same patient at the same time.

LOCAL TREATMENT.

This is the treatment applied to local lesions, such as the chancre, the bubo, and the mucous patch to relieve pain, combat complications and to prevent deformity. Local treatment must always be reinforced by specific and general treatment.

The local treatment of a chancre depends upon its variety, the simple superficial lesion requiring different management than lesions of the phagedenic type. The first question that arises is whether or not it is advisable to excise the chancre. Some authorities claim that if the lesion is excised sufficiently early, the disease will be aborted, or if the symptoms do develop they will be comparatively mild. Other authorities claim that the disease is neither aborted nor diminished in severity by this operation. The present generally accepted view is that the disease is never local, but is constitutional from the time of the inoculation, and, therefore, the excision can not be depended upon to abort the disease. There are many cases on record where the abrasion received during coitus was immediately cauterized, and others where the chancre was excised the day it was discovered. In none of these cases has it been proven that syphilis was prevented. In certain instances it may be wise to excise the chancre, but it should be regarded as simply a palliative operation. When the sore occurs on a long prepuce or other accessible location, excision and suture may hasten healing and save considerable annoyance and pain. As a general rule, the only treatment a simple chancre requires is protection and cleanliness. The use of the black or yellow wash, both time-honored remedies, has a good psychologic effect. If you wish to see the difference in the behavior of a chancre when treated with "wholesome neglect" and "meddlesome officiousness," take two cases and leave one to nature and cauterize the other with nitrate of silver and afterwards apply some greasy salve. The untreated lesion will heal first.

In phagedenic chancre, however, it is necessary to use heroic measures to destroy the infection and prevent sloughing. It should be thoroughly cauterized and afterwards treated with moist antiseptic dressings, such as a bit of cotton wet with chloral solution. Every practitioner should select a cautery early in his professional life and continue to use it until he is familiar with its action. The two agents giving the best results are fuming nitric acid and the actual hot iron. The part should be disinfected as if for a surgical operation, anesthetized by a hypodermic injection of cocaine, and then burned with either a drop of nitric acid on the end of a glass rod or by a metal point heated to a cherry-red color.

The Paquelin thermo-cautery is the best, but in its absence a piece of wire, or a nail fastened in a cork as a handle and heated over a Bunsen burner or alcohol lamp will make an efficient substitute.

Be sure to instruct your patient to give the penis rest by avoiding sexual thoughts, as well as sexual action. Also tell him to handle it as little as possible. The more often he examines it to see how it is getting on the more be retards the final healing of the lesion.

The local treatment of the syphilitic bubo, or enlarged lymph nodes in the immediate neighborhood of the primary sore, requires the same masterly inactivity as indicated above. They are painless, do not suppurate, and will disappear spontaneously if they are let alone. If the mental condition of the patient is such that you have to do something to satisfy him, then considerable psychic impression may be made without physical harm by the local use of iodine. Do not give the patient a prescription and let him make the application himself, but place him on a table and with a camel's-hair brush carefully encircle each gland, using the tincture cautiously, as if too much of the drug would do harm. To the young practitioner this would savor of charlatanism, but the older members of the profession have learned that they have frequently to use placeboes in order to retain their patients until the proper time comes for active treatment. It is an old saying that when a doctor is called to see an anxious mother and a young baby, he has to treat the baby in order to relieve the mother. Frequently the only practical difference between the methods of a skillful and conscientious practitioner and an arrogant quack is that the former realizes what he is doing and the other does not.

The local treatment of syphilitic sore throat should be carried out by means of gargles, sprays, and topical applications. A saturted solution of chlorate of potash is as good as any other gargle; a dilute solution of muriatic acid may be employed as a spray; a mixture of glycerin and tincture of the chloride of iron as a topical application. If there is much pain cocaine may be used.

The local treatment of mucous patches is a subject of importance, as the lesions are not only foul and loathsome to the patient, but a frequent medium of communicating the disease to others. The most efficient plan to follow is to wash the part affected, thoroughly dry it with absorbent cotton, and then apply to the lesion the pure acid nitrate of mercury. Occasionally this is not well borne, and should inflammation develop the part should be painted with compound tincture of benzoin. This acts not only as a stimulant and antiseptic, but makes an efficient protective dressing.

The local treatment of alopecia may usually be met by the use of one of the many proprietary hair tonics on the market. If the hair is falling out rapidly, however, and leaving patches of baldness, then the patient's head should be shaved and his scalp washed with hot water and green soap night and morning. Friction in the form of massage, and perhaps faradism, will prove beneficial.

Most beginners feel embarrassed when called upon to write their first prescription for a hair tonic. Nearly all of them consist essentially of quinine, cantharides, glycerin, castor oil, and bay rum.

Iritis demands the unsparing local use of atropia, which should usually be combined with cocaine and boracic acid applied in the form of eye drops. The great risk when this complication develops is loss of sight from adhesion of the iris to the lens. If this results with a contracted pupil the case is hopeless, whereas if it follows with a dilated pupil, vision can be restored by the use of proper lenses.

Gummata and ulcers, which form in the tertiary stage, do not yield readily to local treatment, but still some good can be accomplished by external applications. As a salve you may use a mixture of calomel and vaselin. If this does no good try painting the part with a solution of bichloride of mercury and salicylic acid in collodion. If this fails, excise or thoroughly curette away the diseased tissue and treat with a moist antiseptic dressing.

SPECIFIC TREATMENT.

This consists in administering to the patient for their constitutional effects one of the many preparations of two drugs—namely, mercury and iodine. These drugs were first employed empirically. They have long been used and have proven almost specific. The manner in which they produce their effect on the system, however, is still a matter of controversy.

Mercury is employed in the secondary stage of syphilis. It is believed that it acts as an antidote because it is an antiseptic. Some, however, claim, that after it has been taken for a long time it is found in the tissues in a metallic form, and that it acts mechanically by opening up lymphatic channels.

One of the most important questions with reference to mercury is when in a given case to begin its use. On this point almost every syphilographer agrees, but for reasons which can easily be appreciated, practitioners often act contrary to their teaching.

If the individual patient probably has syphilis, and if the early administration of mercury will prevent the development of telltale symptoms, the sympathies of the doctor will often overcome his better judgment and the drug will be prematurely employed. No man can say positively that any patient has syphilis until the secondary symptoms develop.[1] If the mercury is given merely because the individual has a suspicious sore and the enlargement of neighboring lymphatic nodes, the correctness of the diagnosis of syphilis will eventually inevitably be questioned. Either the man had syphilis or he did not have it. The mercury has masked the symptoms so that the question is left in doubt; the danger is that he is either treated unnecessarily for years for a disease, which he did not have, or else the treatment is withdrawn too early, and the mistake is not discovered until the development of hopeless tertiary lesions.

The proper plan, when a patient comes to you with a suspicious sore, is to give him some local treatment and some inert internal medicine and tell him to return at a stated period. If the secondary symptoms do not develop he is not made to share your anxiety; if the secondary symptoms do develop there is plenty of time to treat him constitutionally. Do not fear that he will leave you for another doctor because of your lack of frankness. He does not wish to take an additional confidant.

In prescribing mercury we have various preparations from which to choose—namely, calomel, blue mass, bichloride, biniodide, protiodide, the ointment, and the oleate. The drug may be administered by the mouth, by inunction, by fumigation, or by hypodermic injection. The mouth is the most satisfactory avenue of introduction, and the protiodide the most reliable preparation. The dose will have to be determined for each patient Write for one hundred pills containing one-fourth grain each. For the first three days give one pill after each meal; at the end of the third day give two after breakfast, one after dinner, and one after supper; at the end of the sixth day give two after

[1]At the present time many practitioners rely upon the discovery of the spirocheta pallida.

breakfast, two after dinner, and one after supper, and so increase the dose one pill every three days until the premonitory signs of mercurialism are noted. As soon as the patient complains of his teeth feeling too long, his gums getting sore, or his bowels cramping you know his maximum capacity has been reached. Divide the number of pills it has been found necessary to produce this effect in half and tell him to continue to take that number regularly day in and day out for a year. In other words, if it takes eight pills to produce incipient salivation, the man can not safely take for a continuous time more than four. If it requires twelve pills to produce the above effect, the dose for that patient is six. There are individual differences of toleration in different individuals. The bichloride and the biniodide are usually combined with a bitter tonic, like the tincture of cinchona, but they often produce irritation of the stomach. Calomel and blue mass are also employed by the mouth, but even when combined with bismuth or opium, they are usually found to cause diarrhea.

If the patient cannot tolerate mercury by the mouth, then it can be introduced by inunction. This is really the best way to employ mercury in the treatment of syphilis. It will be found impracticable, however, in private practice, owing to the trouble and annoyance it gives the patient. The best preparation for this purpose is the 20 per cent oleate of mercury, although the ointment may be used if the patient is poor. A mass of the preparation the size of the tip of the little finger is rubbed in the skin where it is thin, as on the belly, inner side of the thigh, axilla, etc. The treatment should be carried out each night and a different place chosen each time until a circuit is made of the body in order to prevent irritation. Some syphilographers recommend the drug to be smeared on a band, which is worn around the belly overnight; others rub it on the soles of the feet and depend upon friction in walking to cause its absorption.

Mercury may be administered by fumigation, the method being especially valuable when the patient is suffering from an acute lesion of the eye or brain and it is desired to bring him rapidly under the influence of the drug. The method is as follows:

The patient is divested of all clothes and seated on a cane bottom chair. A rubber sheet or coat is thrown around him and fastened closely about the neck so as to envelop him like a tent. A bucket of boiling water is placed under the chair, so that the heat and moisture arising from it may open the pores of his skin. It is then removed and replaced by an alcohol lamp over which is suspended a piece of tin with twenty grains of calomel upon it. The calomel is volatilized by the heat and rises and is deposited on the body. In twenty minutes the patient should be wrapped in a dry blanket and put to bed. Three such fumigations often cause salivation, and hence this treatment should not be employed unless it is imperative to get the patient quickly under the influence of mercury.

Mercury may be given by hypodermic injections. Here the bichloride is usually employed. It may be given in one-sixteenth to one-eighth grain doses, repeated three times daily. The injection should be made deeply into the muscular tissue under careful septic precautions, else an abscess may follow. It is also wise to use a fresh needle at regular intervals, because the mercury so acts on the steel that it becomes brittle and may break.

Mercury is a drug greatly dreaded by the public on account of its abuse in the past, but if given timely, intelligently, and persistenly it will no do harm, and in the end completely cure the patient. Its use is sometimes attended by gastric disturbances or diarrhea. In this case, the symptoms should be combated by the use of bismuth and of opium. Aphthous stomatitis may occur. If so, the drug should be discontinued for awhile and antiseptic mouth washes used. The most unfortunate untoward effect, and one to be carefully guarded against, is salivation. This may be due to an idiosyncrasy, or to the use of too large doses. The first symptom complained of by the patient is that the teeth feel too long and the edges too sharp. The gums are tender, swollen, ulcerated, and bleed easily. Saliva constantly dribbles from the mouth and the fetor of the breath is horrible. Should these symptoms develop stop the mercury, give an antiseptic mouth wash, and prescribe internally a powder consisting of five grains each of chlorate of potash and pulverized sulphur to be repeated four times a day.

Iodine in some of its numerous preparations is used in the tertiary stage of syphilis. It is not an antidote, but acts as an alterative. It does little or no good while the disease is active, but is the remedy for which there is no substitute in the later stages of the disease. As a general statement it may be said that mercury should be given during the secondary stage, iodine during the tertiary stage, and the mixed treatment, or a combination of both, in the period which intervenes between the two, when it is almost impossible to say whether the one has stopped or the other begun.

The tertiary stage of syphilis is really not syphilis, but a condition resulting from syphilis. Iodine acts on the end products, or gummata, causing their disintegration and favoring their absorption and the restoration of tissues to their normal condition.

The preparations most frequently used are the iodide of potash, the iodide of soda, or the iodide of ammonia. Iodide of potash is the most reliable and popular form. Usually it is given in a saturated solution of which one minim is equivalent to one grain. The drug should be commenced in small doses and gradually increased to the point of tolerance. It must be remembered that a drop of the solution is only one-half a minim, and the common mistake should not be made of telling the patient to take so many drops, thinking thereby he gets so many grains. The drug should be given after meals well diluted with water. Enormous doses are sometimes given, cases being on record where patients took as much as 900 grains a day. It is not probable, however, that a dose larger than 180 grains a day can be satisfactorily appropriated by the system.

Like the unpleasant effects of mercury, those of iodine also require mention. Sometimes when first given, even in small doses, it will cause ptyalism and coryza. When long continued it frequently gives rise to "iodism." This consists in a feeling of depression, nervous irritability, ringing in the ears, and rheumamatic pains in the bones and muscles, followed by an eruption of the skin attended by heat and itching. All these evil effects rapidly disappear with the withdrawal of the drug and occasionally may be prevented by the combination of arsenic with it in the original instance.

GENERAL TREATMENT.

While treating syphilis locally and specifically, it is important to prevent the development of complication by imposing certain restrictions, and to maintain the physical condition of the individual at its highest point by regulation of the habits of life and the administration of suitable tonics.

The use of *tobacco,* either chewing or smoking, is bad, as it produces local irritation of the mouth and tends to the formation of mucous patches. Many patients, however, cannot be induced to discontinue a habit, which is fastened on them by long custom, and then the best that can be done is to send them to a dentist to see that the teeth are in thorough order and to direct the regular use of some antiseptic mouth wash. *Alcohol* is also bad, and stimulants should be interdicted, except in the case of a feeble individual, who from use is more or less dependent on them. The *food* should be nutritious in character and abundant in quantity. An eminent authority once stated that the best remedy for syphilis was a French cook. Outdoor *exercise* should be encouraged, as it gives vigor and muscular tone, increases the appetite, and aids digestion. The *clothing* should be light and warm, flannel being worn next to the skin to keep the pores open and make it active. *Warm baths* are useful to insure cleanliness and to aid in the elimination of posions. When circumstances permit, a Turkish bath should be prescribed once or twice a week. *Tonics* should be administered as indicated—iron for anemia, quinine for malaria, and a bitter stomachic for loss of appetite.

The question of the advisability of a trip to the Hot Springs will always be asked by the patient, and the answer must be based on the circumstances surrounding the special case. There is no specific property in the waters, the advantages derived being the removal of the patient from the responsibilities and worries of home and business, the change of climate and environment, the advice of men who have had great experience in the treatment of the disease, and finally the fact that the patient will in his new surroundings carry out instructions that he would not do at home. Despite the advantages mentioned, there are certain objections, which sometimes outweigh them—namely, expense, loss of time, and publicity.

LECTURE XXXVII.

TUMORS—DEFINITION, OLD THEORIES OF NATURE AND ORIGIN, PRESENT VIEWS, CLINICAL AND HISTOLOGICAL CLASSIFICATION, ESSENTIAL AND PREDISPOSING CAUSES, DIAGNOSIS, PROGNOSIS AND TREATMENT.

Tumors, or neoplasms, are new growths pathologic in nature, performing no physiologic function and tending to persist independently of the structures in which they are found. For a long time absurd and erroneous ideas of their nature and origin existed in the minds of the profession as well as the laity. They were thought to be parasites preying on the system; they were believed to be composed of material essentially different from that found elsewhere in the human body, and in some instances they were said to have a distinct circulation of their own. Hippocrates taught that the body was composed of blood, phlegm, black bile and yellow bile, and Galen believed that tumors resulted from the accumulation of one of these humors. Harvey, after the discovery of the circulation of the blood, thought that tumors were produced by the organization of a blood clot. Boerhaave ascribed tumors to the lymph and said cancers were due to a degenerated variety. Hunter was the first to recognize the similarity in structure between tumors and normal tissue and to maintain that they originated by a modification of formative processes. Broussais, early in the nineteenth century, claimed that all tumors, including cancer, were forms of chronic inflammation consequent upon organic irritation. This view, owing to its simplicity and comprehensiveness, at once became accepted, but its supremacy was short lived. Schleiden, with the aid of the microscope, discovered the cellular structure of plants. Schwann demonstrated the analogy in animals. Muller established the fact that tumors were formed of cells, but believed the cells were derived from the blood. Virchow accepted the cellular structure of tumors, but denied that the cells came from the blood. He proved that the cells could not arise *de novo*, but followed biologic laws and were always the result of the division of pre-existing cells. He believed in metaplasia, and taught that a given cell under certain conditions might become an epithelial cell, and under other conditions a connective tissue cell. Cohnheim denied the existence of metaplasia and established the law of the legitimate succession of cells. He classified tumors by referring each to the blastodermic layer from which its cells had origin and advanced a novel and ingenious theory to explain their development.

According to Cohnheim's theory, there must have been in the embryo during its development more cells produced at some point than were necessary for the formation of that particular part. These cells, not utilized in the growth of the embryo, were included by the surrounding tissues, arrested in their development and remained in a dormant condition. If they are later excited into activity they proliferate and form a tumor. This theory has been further elaborated by other investigators, notably Senn, to include not only groups of arrested embryonal cells, but also groups of new cells, the result of the proliferation of adult cells after birth.

Based on Cohnheim's theory, which is almost universally accepted, the term tumor is now used in a more restricted sense than formerly. At one time the word was employed to designate all kinds of swellings. Now a sharp line of separation is drawn between *tumors, inflammatory swellings* and *retention cysts.* The term tumor is restricted now to new growths due to the proliferation of arrested cells, either of embryonal or post-natal origin, occurring without assignable cause and persisting unless surgically removed. The term inflammatory swelling is applied to an enlargement due to the proliferation of mature cells produced by the action of an irritant and tending to subside when the exciting cause is removed. The term retention cyst is applied to a swelling due to the retention in a preformed space of a physiollogic secretion or excretion due to the obstruction of the normal outlet of the space.

Before considering the classification of tumors it is necessary to briefly describe the developing embryo and to review the elementary tissues. After the ovum has been fertilized by the spermatozoön it divides, first, into two cells, next into four, then into eight, and so on until a small mulberry mass is formed. The cells which compose it are embryonal and unlike any cells found in the normal adult body. They soon arrange themselves in three layers—an outer, middle and inner, called the blastodermic layers and known respectively as the ectoderm, mesoderm, and entoderm. Later the cells that compose these layers assume different characteristics in order to make the different tissues of the body. Not only are changes noted in the cells, but changes are also observed in the three blastodermic layers, which infold and double on themselves so as to make either singly or in combination the different structures and organs of the body.

An analysis of the structure of the body will show that it is made up of five classes of cells, each having associated with it a characteristic intercellular substance. These classes or groups of cells with the intercellular structure are called elementary tissues and are: 1. Epithelial. 2. Connective. 3. Muscular. 4. Nervous. 5. Lymphatic.

The connective, muscular and lymphatic tissues are derived from the mesoderm; the epithelial are derivatives of the ectoderm or entodorm, and the nervous are derived from the ectoderm.

CLASSIFICATION OF TUMORS.

The two headings under which tumors are classified are clinical and histological.

1. *Clinical.* Surgeons long ago divided all tumors into two great classes, *benign and malignant.* They observed that certain tumors grew slowly; that they pushed aside surrounding tissues, making of them a capsule; that they were usually freely movable; that they did not cause enlargement of adjacent lymph nodes or form metastases in other parts of the body; that they never

destroyed life unless by mechanical interference with the function of some organ, and that when completely removed they did not recur. They called these benign tumors. They observed that another class of tumors grew rapidly, infiltrated surrounding tissues, were usually fixed and not movable, caused enlargement of adjacent lymph nodes or formed metastases elsewhere and tended to destroy life, and usually recurred, no matter how radically removed. These they called malignant.

2. *Histological.* Microscopic study showed that the component cells, which give character to a tumor, simulate or are identical in structure with one of the elementary tissues of the body. In most cases tumors were found to be composed of epithelial tissue, or connective tissue, or muscular tissues alone, and hence could be classified under one of the five great divisions. In one or two instances, however, tumors were found to be composed of a mixture of two or more classes of tissue, and hence had to be classified under the head organoid. Further, a study of the histologic structure of tumors developed the fact that if the essential cell of the tumor simulated the cell of an adult elementary tissue the clinical course of that tumor would be benign, while if the essential tumor cell simulated an embryonal elementary cell the course of that tumor would be malignant.

The following is a histological classification of tumors based on Professor Peple's Notes on Histology:

I. Epithelial Tissue Tumors:

1. Papillomata.
2. Adenomata.
3. Epithelial cystomata.
4. Carcinomata.

II. Connective Tissue Tumors:

1. Myxomata.
2. Fibromata.
3. Lipomata.
4. Endotheliomata.
5. Chondromata.
6. Osteomata.
7. Sarcomata.

III. Muscular Tissue Tumors:

1. Myomata.

IV. Nervous Tissue Tumors:

1. Neuromata.

V. Lymphatic Tissue Tumors:

1. Lymphomata.

VI. Organoid Tumors:

1. Dermoid.
2. Teratomata.
3. Odontomata.

ETIOLOGY OF TUMORS.

Accepting the theory of Cohnheim and the modification of Senn the essential cause which produces a tumor is the existence in the body of dormant embryonic cell groups or dormant groups of young cells of post-natal origin. The exciting causes are conditions which awaken the energies of the latent cells and inaugurate their proliferation. A combination of the two etiologic factors is necessary, for the cell group would remain permanently in a latent condition unless stimulated, and again all intrinsic and extrinsic irritation without a cell group upon which to act would be powerless to produce a tumor.

In considering the causation of tumors it is not proper to leave the subject with merely a statement deduced from Cohnheim's theory, but it is also necessary to state some facts observed by practical surgeons with reference to certain conditions which seem to predispose to their development.

1. *Heredity.* The mysterious influence of heredity, a force transmitted by a single cell to the entire organism by which physical attributes, intellectual powers, moral qualities, and pathological tendencies are transmitted from parent to offspring, markedly influences the occurrence of tumors. Twist the facts as you please, certain tumors occur in families.

2. *Race.* The bearing of race, although not understood, is

equally evident. The negro is prone to fibroid; the Hottentot to fatty tumors, while the Eskimo and Indian do not have cancer.

3. *Age.* Sarcoma is essentially a disease of youth, while carcinoma selects as its victims those past middle life. So constant a factor is age in the development of malignant tumors that it is used as a diagnostic factor in doubtful cases.

4. *Sex.* Each sex is peculiarly prone to tumors of certain localities. Men are apparently more frequently the victim of the disease in extragenital locations than women.

5. *Occupation.* The refined and cultivated are afflicted with tumors more frequently than the lower classes; the higher the civilization the more prevalent the disease.

6. *Climate.* The inhabitants of the tropics and of the Arctic regions are the frequent victims of lipoma, while they are endowed with comparative immunity to carcinoma.

7. *Irritation.* The friction of the suspenders frequently causes a fatty tumor on the back. A long prepuce in an uncleanly individual often causes the development of papillomata and the irritation of a pipe stem has frequently been the starting point of cancer of the lip.

8. *Traumatism.* Injuries, such as a wound of soft structures or a fracture of bone, frequently appear to be the origin of tumor formation, as when a keloid develops in a cicatrix or a bony tumor follows a fracture.

9. *Inflammation.* Infection, especially when followed by suppuration, is apparently the frequent cause of the development of a tumor. Patients will often state that the growth was discovered at the site of the old abscess.

10. *Contagion.* Whether or not tumors are ever due to infection with a microbe or parasite is an undecided question. It will be fully discussed in the lecture on carcinoma.

GENERAL PROPERTIES AND CHARACTERISTICS OF TUMORS.

1. *Shape.* The shape of a tumor is determined by the character of surrounding structures. It grows in the direction of least resistance. It may be oval, round, nodulated, sessile, broad, flat, lobulated, or pedunculated.

2. *Size.* The size of a tumor varies with the structure. Fatty tumors grow very large; myomata of the uterus have exceeded fifty pounds while cystic tumors have actually outweighed their owners.

3. *Density.* The density of a tumor depends upon the variety of growth; an osteoma is hard as bone, while a true myxoma or mucous tumor is soft. Endotheliomata may be quite compressible. Cysts fluctuate.

4. *Color.* The color of a tumor depends upon the kind of tissue of which it is made. A fatty tumor is yellow, a myoma is red, a fibroma is white; certain tumors are made up of pigmented cells which impart color to the mass; a melanosarcoma is black. The vascular supply when very abundant may impart a dark red or bluish color to a tumor.

5. *Growth.* The growth of a tumor depends upon the kind of tumor, the location and its blood supply. Growth in some tumors is unaccountable and erratic. It may advance rapidly, lie unchanged for years, and then progress rapidly again.

CHANGES UNDERGONE BY TUMORS.

Metamorphosis is a term used to designate a change of one kind of tumor into another. This class of change is undergone by normal tissues; for example, the fetal skeleton is cartilage, which changes into bone. The type of tissue, however, does not change; epithelium does not become cartilage nor does muscle change to nerve. The same is true of tumors. A chondroma may undergo ossification, a myxoma may change to a fibroma, but a lipoma does not become an adenoma or a myoma a neuroma.

Malignant Metamorphosis. Benign epithelial tumors may become carcinomatous and benign connective tissue tumors may become sarcomatous by reverting to the embryonic type, a retrograde metamorphosis, if we accept the theory of Cohnheim, or possibly a specific infection of benign tumors by the parasites of carcinoma or sarcoma if we accept the parasitic theory.

Degeneration is a term used to indicate destructive changes which occur in the tumor cells. They may undergo fatty degeneration, the cells being filled with oil droplets; they may undergo cystic degeneration, the cells breaking down and liquefying; they may undergo colloid or mucoid degeneration, the cells being converted into a colloid or mucoid substance. Finally they may undergo calcareous degeneration from a deposit of lime salts.

Ulceration is seen especially in superficial malignant growths that reach the surface. It is a molecular necrosis, or gangrene, from restricted or obliterated blood supply, and exposure of unprotected cells to air and injury. Inflammation and suppuration are due to specific infection and are accidental complications in connection with tumors.

THE COURSE OF TUMORS.

The clinical course of tumors will depend on the nature of the tumor, the age of the individual, the location of the growth, and the external and internal influences to which it is subjected. If it is benign it tends to persist and only endangers life by its bulk; if malignant it tends to destroy life by invading and destroying surrounding tissues and by migration to other parts of the body.

DIAGNOSIS.

The diagnosis of a tumor is based on the clinical history of the patient, a careful physical examination, and finally by an exploratory incision, the removal of a small piece of the tissue and its examination with the microscope.

PROGNOSIS.

This depends on the type of tumor. It is good in the benign, but bad in the malignant variety. The prognosis also depends upon the anatomic location—that is, whether or not it is easily accessible—and upon the age, strength, and general health of the patient.

TREATMENT.

Medical. There is not a single case on record where a true tumor has been cured by either the external or internal use of drugs. The only purpose served by medicines in the treatment of tumors is to establish a diagnosis, relieve pain or build up the general health of the patient.

2. *Surgical.* This consists in the radical extirpation of the growth, the character of the operation depending upon the location of the tumor and whether it is benign or malignant. The subject will not be enlarged upon as it belongs properly to practice of surgery.

LECTURE XXXVIII.

BENIGN TUMORS — PAPILLOMA, ADENOMA, CYSTOMA, MYXOMA, FIBROMA, LIPOMA, ENDOTHELIOMA, CHONDROMA, OSTEOMA, MYOMA, NEUROMA, LYMPHOMA, DERMOID, TERATOMA, AND ODONTOMA.

Benign tumors do not tend to destroy life; they do not form metastases or cause enlargement of adjacent lymph nodes; they are usually encapsulated and often movable, and they do not infiltrate surrounding structures.

I. BENIGN EPITHELIAL TUMORS.

These include the papilloma, adenoma, and epithelial cystoma. They are derivatives of the ectoderm and entoderm and simulate maturely developed or adult epithelial structures.

1. *Papillomata* receive their name from the fact that they are usually developed from a papilla of the skin or mucous membrane. The term is more broadly used, however, to include benign epithelial new growths which are not structurally like glands.

(*a*) *Squamous Cell Papillomata* occur on surfaces covered by squamous epithelium. When on the skin they are called warts and are composed of stratified squamous epithelium with an outer horny layer; when on mucous membrane, as in the bladder, they are soft, sponge-like and bountifully supplied with blood. They bleed profusely at times without apparent injury and unless very completely removed are apt to return. Papillomata of the mucous membrane should not be regarded lightly as they may degenerate and become malignant.

(*b*) *Columnar Cell Papillomata* spring from surfaces covered with columnar epithelium, such as the lining of the stomach intestines and uterus. They are rarer than the squamous variety. They are most frequently seen in the rectum and uterus in the form of polypi. They give rise to bleeding and may undergo malignant degeneration and should be early and radically removed.

2. *Adenomata*, or glandular tumors, are new growths which simulate normal glands. They consist of tubules or acini, or both, embedded in interlobular connective tissue which furnishes limiting membranes for the essential tumor cells. Since the normal lining of tubules and acini is columnar, cuboidal, or polyhedral cells, similar types, are naturally found in adenomata. The two salient points to be borne in mind in examining this class of tumors are that the cells are mature cells, not embryonal, and that they lie evenly upon their basement membrane and do not break through and form nests in the intertubular connective tissue. Glandular tumors may occur in any of the glands of the skin or mucous membrane. They are also found in the breasts of young women and are here distinctly encapsulated. They are not of rapid growth, usually present a nodular appearance and are inelastic to the touch. They are liable to undergo cancerous degeneration and, therefore, should be removed.

3. *Epithelial Cystomata* are tumors composed of a cyst wall and cyst contents, the cyst wall being formed of epithelial cells and the cyst contents being a fluid secreted by these cells. Cystic tumors are new growths and should not be confused with retention cysts, which consist of fluid in a preformed space. Cystomata are oval or spherical in shape, smooth in contour and impart a sense of fluctuation upon palpation. The capsule may be thick or may be thin from pressure. When but one collection of fluid exists the tumor is said to be monolocular; when more than one exists it is said to be multilocular. The contents of a cystoma vary with the origin of the epithelium making up the lining of the tumor. It may be clear like serum, glairy like mucus, or thick and ropy like colloid material. It also varies in color from a clear white to yellow, green, or black. Cystic tumors occur in many glands, such as the breast and thyroid; also in the ovary and in fetal epithelial remnants.

(*a*) *Cystomata of the Breast* are generally associated with glandular overgrowth; they seldom attain large size, but may be so tense as to feel like a solid tumor. They are usually well encapsulated. They should always be removed when diagnosticated.

(*b*) *Cystomata of the Thyroid* consists of a cyst wall and cyst contents developed in the thyroid gland. The cyst wall is of new growth and the cystic contents a fluid of colloid character. Such tumors can usually be enucleated without excision of the lobe of the gland in which they occur.

(*c*) *Ovarian Cystomata* are tumors of the ovary due to failure of a mature Graafian follicle to rupture. They seldom attain a size larger than the fist and are almost invariably monolocular. When only one ovary is the seat of growth the organ itself should be removed; if both are involved the cysts should be resected and a portion of one or both ovaries left.

(*d*) *Parovarian Cystomata* arise from certain fetal remnants in the shape of small ducts lined with epithelium and located near the ovary. As their lining is a columnar epithelium, the cyst wall is of this type. These tumors grow to such a large size that in dealing with them the ovary is usually lost sight of. Cases are on record where they have weighed over 100 pounds. They are sometimes monolocular, but usually multilocular. The fluid with which they are filled varies in character with different tumors and in different compartments of the same tumor.

(*e*) *Intraligamentous Cystomata* belong to the same class of tumors as the above. They develop between the folds of the broad ligament, are usually bilateral, and their removal is often extremely difficult.

(*f*) *Atheromatous Cystomata* are cysts which, owing to the degeneration of the epithelial cells composing its walls are filled with a thick, oily material. They occur beneath the tongue, in the orbital region, and in the ovary. They must be dealt with by complete extirpation or by incision and the destruction of the cyst wall by packing or the use of escharotics.

(*g*) *Branchial Cysts* are cystomata occurring in the neck from imperfect closure of the branchial clefts. Their cure can only be effected by the removal or destruction of their epithelial lining.

II. BENIGN CONNECTIVE TISSUE TUMORS.

These include the myxoma, fibroma, lipoma, endothelioma, chondroma and osteoma. They are derived from the mesoderm and simulate developed or adult connective tissue.

1. *Myxomata* are tumors formed of mucous tissue, such as is seen in the vitreous humor of the eye or Wharton's jelly of the umbilical cord. The essential tumor cells are stellate or spindle shaped with tapering filaments. There are also oval and round connective tissue cells scattered without apparent plan or purpose throughout the homogeneous matrix. True myxomata are not common. They occur wherever loose fibro-elastic tissue is abundant; in the sub-epithelial nasal mucosa, in the labia majora of the female, in the intramuscular spaces especially of the thigh, and in the inguinal canal springing from the periosteum of the ileum or fascia of the rectus. They present a smooth, rounded surface free from nodules with a semi-elastic structure like that of a fatty tumor. They do not always possess a well-defined capsule. They are often very vascular. A differential diagnosis between a myxoma and lipoma is usually impossible before operation. The treatment consists in complete removal, as sarcomatous degeneration often takes place.

2. *Fibromata* are tumors made up of fibrous tissue. They consist of bundles of fibrous tissue compactly placed, always wavy in outline, with a tendency to form whorls. The cells are usually scanty in number and irregularly distributed among the bundles. The fibers are analogous to those found in fibro-elastic tissue, but are always more compactly arranged than in any normal structure. Fibromata are most frequently found springing from the connective tissue elements of the skin, especially of the neck, chest and upper extremities. Following the direction of least resistance, they often become pedunculated; the epidermal covering is quite smooth and not horny, thus distinguishing them from the ordinary wart. Fibromata are also often found in the uterus, in the prostate, and springing from the periosteum of bone.

(*a*) *Multiple Subcutaneous Fibroma* is the name given a special kind of tumor connected with the sheaths of terminal nerves.

Thousands of these tumors varying in size from a millet seed to a hickory nut are sometimes seen in one patient.

(*b*) *Keloid* is the name given to a fibrous growth which occurs in scars on the skin of certain individuals. The growth usually returns if removed, not due to malignancy, but to the peculiar tendency of the individual which caused the growth in the original instance.

3. *Lipomata* are tumors formed of fat, the masses of cells being divided into lobes and lobules by connective tissue. Fatty tumors occur in the subcutaneous connective tissue of the shoulders, neck, back and arms and are occasionally found attached to the fascia muscles.

(*a*) *Circumscribed Lipomata* are round, semi-elastic, smooth, movable tumors having a distinct capsule. They are sometimes very large, weighing thirty or forty pounds. They are often multiple. Some cases are reported where they have developed behind the peritoneum in the region of the kidney and have been mistaken for sarcoma of that organ.

(*b*) *Diffuse Lipomata* are fatty tumors with a broad base with no distinct capsule. They send irregular projections into the surrounding connective tissue which render their removal extremely difficult. They are often seen in the neck, sometimes in the shape of a collar.

Fatty tumors are not difficult to diagnosticate, although they may be confused with large, tense sebaceous cysts. They grow slowly, are painless, seldom become inflamed, and never undergo malignant degeneration. Circumscribed lipomata are readily enucleated from their capsule and may usually be removed under cocaine and anesthesia. The diffuse form, however, often requires tedious and difficult dissection.

4. *Endotheliomata*, or benign endothelial tumors, simulate normal blood vessels, lymph vessels, or lymphatic spaces and are called, respectively, hemiangiomata, lymphangiomata, and endothelial cystomata. The structural elements are the endothelial cells and its associated white and yellow fibers. Microscopically, these new growths consist of thin walled vessels and spaces of fibrous connective tissue lined with flattened plates. The cavities

are filled with blood or lymph and connected with blood or lymph vessels. The term cavernous is applied to both blood and lymph vessels when they form thin walled spaces, such as are seen in normal cavernous or erectile tissue.

(*a*) *Hemiangiomata* occur most frequently in the connective tissue of the skin and mucous membrane. They are commonly known as nevi, or "mother's marks." They vary in color from a bright scarlet to a port wine and in area from a pin point to a large patch. They may be noticed at birth or develop during growth.

(*b*) *Lymphangiomata* are structurally identical with hemiangiomata, except that they contain lymph and communicate with lymph vessels. They occur in the tongue, giving rise to the condition called macroglossia, in which the organ becomes so much enlarged as to protrude from the mouth. They also occur on the mucosa of the palatine arch and on the uvula.

(*c*) *Endothelial Cystomata*, or mesodermic cystomata are large lymph spaces filled with fluid. They occur most frequently in the neck, where they receive the name of hydrocele of the neck. They are also seen in the perineum and axilla.

The treatment of endotheliomata varies with the size and location of the growths. They may be dissected out, destroyed by electrolysis or the actual cautery, or strangulated by a pin and ligature. Large cystomata may be removed by dissection, by opening and packing, or by the injection of some irritant to destroy their lining.

5. *Chondromata* are tumors composed of cartilage. The hyaline type is far the most common, but tumors of fibrous cartilage have occasionally been noted. Chondromata usually spring from cartilage or bone, but they may have origin in connective tissue trabeculæ of such organs as the parotid gland, testicle, or kidney where no cartilage normally exists. Chondromata occur in young people in whose cartilaginous tissue active changes are going on in the process of bone development. They are found on the epiphyses of long bones, especially the phalanges of the hands and feet, and on the bony septum of the nose. They are hard, unyielding tumors encapsulated with fibrous tissue which

makes a perichondrium for them. They are usually nodular, lobulated, and are generally multiple. They readily undergo myxomatous degeneration; they may develop into a sarcoma or become ossified into bone. Chondromata, especially when they arise in the parotid or testicle, should be removed. When they spring from the epiphyses of long bones they should be attacked with caution, especially if the patient be young, as the injury done in their excision may destroy the normal centers of ossification and arrest growth.

6. *Osteomata* are bony tumors. They consist of connective tissue cells embedded in a calcified matrix and show the typical histological structure of true bone. Osteomata are formed either of compact bone or spongy bone, the difference being in the arrangement of the structural elements. The compact type is found springing from cranial bones and the shafts of long bones; the spongy type usually arises from the epiphyses of the long bones. Osteomata are hard, dense, immovable tumors which grow slowly, give little pain and never affect the general health. Their treatment should be governed by their location and the amount of mechanical trouble they cause. Their removal is often difficult and should not be undertaken lightly.

III. MUSCULAR TISSUE TUMORS.

1. *Myomata*, or benign muscular tissue tumors include the leiomyomata, or nonstriated muscular tissue tumors, and rhabdomyomata, or striated muscular tissue tumors. The first is common; the second is rare. Several tumors of the heart muscle have been reported, but they are not distinctive enough to make a third group.

(*a*) *Leiomyomata* are tumors whose essential cells are nonstriated muscle. They are never pure, but occur mixed with fibrous tissue. The tumor cells is a mononuclear spindle cell with tapering ends. Instead of being arranged in sheets or plates the spindles radiate in every direction without plan. The amount of fibrous tissue is variable, often forming a larger proportion of the tumor than the muscle. Leiomyomata are oval or globular and vary in consistency according to the vascularity and the proportion of fibrous tissue they contain. They are found in the uterus and its ligaments, in the labia majora, in the gastro-intestinal and genito-urinary tract. When they occur in the uterus they may attain an enormous size. The growth of these tumors is slow and the symptoms they produce principally mechanical. The treatment consists of their removal; if in the uterus by a myomectomy or hysterectomy; if in the prostate by a prostatectomy; if in the bowel by an enterectomy.

(*b*) *Rhabdomyomata* are striated muscle tumors and are very rare. They are congenital and are found in such locations as the kidney, scrotum, testicle, ovary, parotid gland, and where normally there is no striated muscle. They rarely, if ever, occur in a voluntary muscle. The cells are imperfect spindles and always atypical. Short striped spindles are common, the nuclei are large and are placed in a central dilation of the cylinder or may lie upon the outer side of the cell. These tumors readily undergo transformation into sarcomata, and hence should be removed as soon as diagnosticated.

IV. BENIGN NERVOUS TISSUE TUMORS.

1. *Neuromata,* or tumors of the nervous system, except those composed of neuroglia, may be divided into three classes: Neuronomata, or tumors composed of new nerve cell bodies, or whole neurons; neuraxomata, or tumors composed of new nerve fibers or neuraxes; and neuraxo-fibromata, or tumors in which the fibrous tissue of the nerve trunk constitutes the new growth.

(*a*) *Neuronomata,* or tumors composed of nerve cells, are very rare and are practically found only in the sympathetic nervous system. They vary in size from a millet seed to a small apple.

(*b*) *Neuraxomata,* or tumors composed of nerve fibers, occur in the circoid and plexiform neuromata. They are found on the head, trunk, and extremities and may be large enough to distort the part.

(*c*) *Neuraxo-fibromata,* or tumors caused by an increase of the connective tissue of the nerve trunk, occur as a globular or fusiform enlargement in the trunk of a nerve or at the end of a divided nerve. In the last case it is spoken of as an amputation neuroma. They are composed almost entirely of fibrous tissue and are frequently very painful. If they give rise to symptoms which justify it they should be removed. The operation is a simple one when the growth is at the end of a divided nerve. If it occur in the trunk of a nerve care should be taken to remove it without destroying its continuity, or if this be found impossible, the nerve should be resected and then carefully sutured.

V. BENIGN LYMPHATIC TISSUE TUMORS.

1. *Lymphomata* are tumors composed of lymphatic tissue. The majority of writers deny the existence of benign lymphatic tissue tumors, and claim that all such enlargements, when benign, are inflammatory. Enlargements of the lymph nodes that cannot be attributed to infections, or cannot be shown to have relation to general systemic disease, must, however, be classed as tumors. Microscopically, a lymphoma cannot be distinguished from an enlarged node due to infection. Lymphomata always have origin in a lymph node and are never found where lymphatic tissue does not exist normally. They are most frequently seen in the neck, axilla, groin, etc. Whenever discovered they should be removed for fear of malignant degeneration.

VI. BENIGN, COMPLEX OR ORGANOID TUMORS.

The tumors heretofore considered simulate the simple or elementary tissues and were each derived from one of the primary layers, and were therefore called simple or elementary or histoid tumors. The class now to be considered simulate complex structures or organs and are made up of two or more elementary tissues put together without plan. They are derived from two or three of the primary layers and are, therefore, called complex or organoid tumors.

1. *Dermoid tumors* are tumors composed of skin and are derived from the ectoderm and mesoderm—the ectoderm furnishes the epithelium and the mesoderm the underlying corium. Der-

moid tumors are usually cystic and contain products of glandular secretion, degenerated cells resembling sebaceous matter and hair. Embryonic inclusions from which dermoids develop are usually due to faulty closure of fetal clefts. They occur upon the face and neck and various parts of the body. Near the tip of the coccyx is a frequent site. They are also found in the ovary and in the scrotum.

2. *Odontomata*, or tooth tumors, are derived from developing teeth. They are composed of enamel, dentine and cementum. They are dense in structure, irregular in shape, and rarely exceed a normal tooth in size. They may project through the gums along with the teeth, or they may remain embedded in the substance of the alveolus.

3. *Teratomata* are circumscribed new growths, consisting of two or more elementary tissues put together without plan. They may consist of bone, cartilage, fat, fibrous tissue, striated and unstriated muscle cells, nerve cells and fibers, bits of skin, teeth, and groups of gland cells in purposeless confusion. They are found in the nose and throat, jaw, in the cervix and vagina, and in the neck and abdomen.

LECTURE XXXIX.

MALIGNANT TUMORS—THE CELLULAR VERSUS THE INFECTIOUS THEORY OF MALIGNANT GROWTHS — CARCINOMA — PATHOLOGY, VARIETIES, SYMPTOMS, DIAGNOSIS, PROGNOSIS.

Malignant tumors are pathologic new growths composed of embryonal cells which tend to destroy life. There are two theories as to their origin. First, the Cellular, or Cohnheim's Theory; second, the Infectious or Parasitic Theory. Each counts among its advocates some of the foremost thinkers and workers of modern times. The followers of Cohnheim cling to the theory of an arrested group of embryonal cells awakened into activity by an exciting cause, the cells retaining embryonal characteristics and developing destructive tendencies. The followers of the parasitic theory claim that malignant growths are due to specific parasites which incite certain tissue cells to an inordinate reproduction, probably as a defensive measure. They wish to take them out of the tumor class and put them among the inflammatory swellings, as has been done with syphilis, tuberculosis and leprosy.

The champions of the cellular theory state that, despite the fact that earnest workers in all parts of the world have investigated the subject, no one has yet succeeded in isolating an organism that can be propagated and will produce a malignant growth when injected in man; further, that while numerous cases of accidental inoculation with tuberculosis, syphilis and other recognized microbic diseases are on record, there are no authentic cases where surgeons have been inoculated with cancer, although from the nature of their work they are constantly exposed to infection. They claim that a pathologic study of cancer argues against its being a parasitic disease. When, for instance, cancer originates in the breast and becomes transported by metastasis to the liver, the second growth will have the same histological structure as the first—namely, will be composed of breast cells—while in an inflammatory disease of the breast, if metastasis occurs, the new cells found in the liver will not be breast cells, but those characteristic of ordinary hepatitis. Nicholas Senn in a public clinic in order to prove his conviction that cancer was not infectious, made an incision in the middle of his forearm and implanted a section of carcinomatous tissue recently removed from a patient with unquestioned malignant disease. In the course of a week a nodule the size of a pea made its appearance, which remained stationary for ten days and then disappeared.

On the other hand, the advocates of the infectious theory of cancer present strong arguments to substantiate their position. They admit that the exact nature of the organism has not been demonstrated, but believe it to be a parasite whose peculiarities and habits of life are not yet understood. Sarcoma in the rat and carcinoma in the mouse have been transmitted by implanting pieces of the tumor in healthy animals. Gaylord and Clowes, of New York, have proved that rats and mice placed in cages previously occupied by animals infected with sarcoma and carcinoma will contract the disease. Pick, of Germany, reports an epidemic of cancer in brook trout confined in certain tanks. Wild fish placed in these tanks developed the disease. Smith, of Montreal, reports one house in which six people developed cancer, and he also publishes numerous instances where people with cancer-free histories have apparently contracted cancer by intimate contact with infected individuals. The controversy is still going bravely on and it would be unwise to hazard an opinion as to the ultimate outcome. Possibly an entirely new theory may be evolved.

The present tendency is to accept the view of the infectious origin of malignant growths, the organisms being supposed to be protozoa, rather than bacteria. This explanation is certainly more plausible than that of a group of cells gone mad. If the cellular theory is accepted, the essential tumor cell of a malignant growth is endowed with many strange properties and characteristics. It never reaches maturity, but expends all its energies in reproducing new cells identical with itself. These cells have the power to infiltrate surrounding tissues and destroy them, and to migrate by way of the blood and the lymph stream to distant parts of the body, and to establish new colonies of cells with like properties. They are the "lesser breed without the law," intent upon destruction. They kill finally by hemorrhage from corroding blood vessels, or by the slower process of filling the system with poisons, the products of cell destruction. If we adopt the cellular theory we must accept three classes of cells as possibly existing in every human being: (1) Normal cells—good, law-abiding citizens; (2) benign tumor cells—petty criminals; (3) malignant tumor cells—murderers. If the cellular theory is correct, the future holds nothing in store for the human race as far as the mortality from malignant tumors is concerned except in earlier diagnosis and in earlier and more mutilating operations.

If the infectious or parasitic theory is accepted the malignancy of the growths in question would meet with ready explanation and would find a multitude of analogues in other infectious diseases. Park states that metastasis is regarded as the principal evidence of infectiousness in all microbic diseases from the most acute of the septic and pyemic type to the slower manifestations of tuberculosis. The similar manifestations in maglinant tumors is like evidence of their infectiousness. If it means anything in one case it has exactly the same meaning in the other. As a surgeon watches a case of melanotic sarcoma of the leg and sees the gradual transmission of the disease up the limb, and becomes still aware of the involvement of the liver, then of the lungs, and then of the various other parts of the body, how can he help but say that this is a disease which travels along the same paths and after the same fashion as does tuberculosis? Or when he sees *cancer en cuirasse* following an operation for carcinoma of the breast, how can he avoid the conviction that he has here to deal with a slowly creeping infection which is gradually extending and traveling, as only an infection can? If the parasitic theory is correct, a time will come when the habits and modes of transmission of the organism will be known. The diagnostician will then have exact methods of demonstration and the therapeutist will be able to combat the disease logically, and, therefore, successfully.

The two great classes of malignant tumors are carcinoma and sarcoma, and while possessing many points in common, they have more that are in distinct contrast. The growths are not encapsulated; they infiltrate surrounding tissues and become fixed; they grow rapidly and tend to recur when removed. Carcinoma is a disease of middle and later life; sarcoma is a disease of the young. Carcinoma is composed of embryonal epithelial cells and is disseminated through the lymphatics; sarcoma is composed of embryonal connective tissue cells and is disseminated by means of the blood vessels. The stroma of carcinoma is composed of fibrous connective tissue which is often very abundant. The stroma of sarcoma varies with the type, is usually scanty and is often demonstrated with difficulty. The blood vessels in carcinoma possess well-defined walls, while in sarcoma they are ill defined spaces, with tumor cells bordering the blood stream. Carcinoma is supplied with lymphatics; sarcoma does not possess them.

CARCINOMA.

Carcinoma or cancer is a pathologic new growth composed of embryonal epithelial cells, which tends to persist and to destroy its host by infiltrating surrounding tissues and organs, by establishing metastasis in adjacent lymph nodes and in distant organs, and by setting free toxic substances which produce a train of symptoms known as the cancer cachexia. The word carcinoma means a crab, and the German name for it is krebs, also meaning a crab. The name was given to cancer from the way the growth fixed itself into tissue by tentacle-like projections.

Pathology of Cancer. Cancer starts in epithelium. The essential cell of cancer is an immature epithelial cell. The nearer it approaches the adult type, the less malignant will be its course. Cancer cells are atypical. Individually, the nuclei show unequal amounts of chromatin; collectively they exhibit a tendency to break through basement membranes and to burst normal bounds, and physiologically their function is abnormal, for a group of embryonal cells in cancer of the liver do not secrete normal bile.

The Stroma of Carcinoma. All epithelium rests upon, or is associated with, fibrous connective tissue, and this form of tissue is found as a non-essential part of cancer, just as the capsule and trabeculæ are the non-essential parts of a normal gland. It is called the stroma of the growth, and it is very variable in amount. When the stroma greatly preponderates, the tumor is a hard, fibrous mass, and is called scirrhous cancer. When there is little or no stroma, the mass is soft like brain tissue, and hence is termed encephaloid cancer. The stroma of carcinoma often divides the tissue into compartments each filled with cells which lie in immediate contact one with the other, giving the fancied resemblance to eggs in a nest.

The Blood Supply of Carcinoma is usually abundant. The vessels ramify in the connective tissue stroma and send twigs to the nests of cancer cells. The vessel walls are well defined and are in marked contrast to the imperfect channels seen in sarcoma. Lymph clefts and lymph vessels are also plentiful in the stroma and furnish the growth with a means of dissemination.

The Course of Carcinoma. Carcinoma begins as a small proliferating area in epithelium, which slowly or rapidly enlarges and invades surrounding tissues and organs. It follows the lymph channels and is checked for a time in neighboring lymph nodes. When these barriers are overcome, it localizes in other nodes connected with the same lymph channels. When by ulceration into a blood vessel, malignant cells gain access to the circulation, the new growths become widely disseminated. The secondary or metastatic growths are always composed of the same kind of cells which make up the parent tumor. If the original tumor be a squamous celled carcinoma of the nipple, the axillary nodes will show nests of squamous cells, and if it next lodges in the liver the new focus will also show squamous cell groups.

Cancer may undergo both fatty and mucoid degeneration. It is also prone to ulcerate, especially when on a free surface. When cancer has existed for a long time the patient shows a characteristic group of symptoms spoken of as the cancer cachexia.

There is emaciation, muscular weakness, loss of appetite, and a peculiar yellow or sallow color to the skin. This is due to an intoxication with the products of cell destruction. Cancer finally kills by exhaustion or hemorrhage.

Location of Cancer. Cancer may be found wherever epithelium occurs—the skin, mucous membrane, glands, congenital epithelial remnants, benign epithelial tumors and in the chorionic villi.

Varieties of Cancer. (1) *Squamous Celled Carcinoma* occurs as a primary growth on surfaces covered with squamous epithelium, such as the skin and mucous membrane. The cells are mainly young cells. They show here and there atypical mitotic figures and there are many more rows than in the normal structure. In benign squamous celled papilloma the row of cells next to the basement membrane is columnar as in a normal structure. In carcinoma, the basal cells are spherical or polyhedral and at some points the cells burst through the basement membrane, forming tongues of new cells projecting into the stroma. There may also appear here and there in the connective tissue isolated groups of epithelial cells. The older whorls of cancer cells which take stain poorly from having become more or less horny scales are called pearly bodies.

EPITHELIOMA.

(*a*) *Skin Cancer,* as epithelioma of the face, is the most frequent variety of squamous celled carcinoma. It forms an ugly, indolent, crusty ulcer on the nose, eyelid, temporal or other region. It is usually of slow growth and comparatively painless. It is slow to form metastases and is the variety most amenable to treatment.

(*b*) *Orificial Cancer* is a name given to cancers occurring at orifices, such as the lips and anus, points at which mucous membrane fades into skin, or at the cardiac orifice of the stomach where the esophageal scales are replaced by the simple columnar epithelium of the gastric mucosa. Owing to rich supply of lymphatics they tend to rapid extension.

(2) *Columnar Celled Carcinoma* occurs in localities where columnar epithelium is found—the nasal and other air passages, the gastro-intestinal tract, the gall bladder, uterus and ducts of glands. Columnar celled carcinoma occurs oftenest as a villous growth—that is, the cells are arranged on the outside of the stroma like the leaves on the stalk of a fern. It may also simulate the ducts of glands and is then quite difficult to distinguish from gland celled carcinoma.

(3) *Gland Celled Carcinoma* has its origin in the secreting cells of glands, and hence is very widely distributed. It is found in the breast, uterus, liver, parotid, pancreas, thyroid, in the gastric and intestinal glands, etc. Gland celled carcinoma simulates a gland. The essential cells are embryonal gland cells and the structure is essentially acinous. Since there is no characteristic shape to gland cells and the shape of the cancer cells is oftenest spherical, the name spheroidal celled carcinoma is often applied to this type. In a stroma of varying amount are seen the new formed gland acini, usually lined with more than one row of cells and often blocked with a plug of cells which fill the whole lumen, and here and there break through the basement membrane into the outlying stroma.

Symptoms of Cancer. These vary with the location of the disease and the length of time is has existed. In superficial cancer, swelling is, as a rule, the first symptom; in concealed cancer, perverted function, such as hemorrhage in uterine, or dyspepsia in gastro-intestinal cancer. Pain, unfortunately, is a late symptom. If cancer were inaugurated with bitter, agonizing pain, there would be more prompt diagnosis and more efficient treatment. Lymphatic involvement is comparatively early, but often not sufficient to make it palpable until the disease is far advanced.

The Diagnosis of Cancer is based on the history of the case and the character of the growth. A hard, fixed, nodular tumor occurring in an epithelial structure in an individual past forty years of age should be considered cancer until it is positively disproven. The race, sex, location, family history, previous local injury or inflammation should all be taken into account

Adjacent lymph nodes should be carefully palpated, and finally, a specimen should be obtained for microscopic examination, and this report should be used as a most important factor in arriving at a diagnosis.

Prognosis of Cancer. The prognosis of cancer depends upon a combination of many factors.

The character of the growth has much influence, as it has been shown that the more embryonal the cells, the greater the malignancy, while the more nearly they approach the fully developed cell the less the malignancy.

The location of the growth is also important. If superficial, an earlier diagnosis and more prompt treatment is possible than when it is deep. If it involves an organ which can be removed, such as the breast, it is better than when it affects an organ like the liver. If it begins in tissue poorly supplied with lymphatics, such as the skin, it disseminates more slowly than when it attacks structures rich in lymph circulation.

The age of the patient influences the course of the disease. It is a well-known fact that cancer progresses to a fatal termination more rapidly and certainly when it attacks the young than when it affects the old. As far as prognosis goes, the older the patient, the better. The explanation is probably found in the fact that the lymphatic system atrophies with age.

An early diagnosis and radical operation is the most important element in the determination of the patient's fate. Cancer is at first local, later becomes regional and finally constitutional. A case that at first was curable soon becomes incurable as a result of delay.

At the present time about 30 per cent of cases of carcinoma are cured and about 70 per cent die. This result is better than it was in the past, but nothing like as good as it will be in the future. The obstacles to the achievement of the highest degree of success have been: First, the failure of the family physician, when consulted by a suspicious case, to appreciate the necessity of an immediate consultation, and, if necessary, operation; and, second, the general belief among the laity that cancer is something to be ashamed of; and as it is a hopeless disease, its existence should be hidden and concealed. The education of the general profession with regard to carcinoma has now overcome the first difficulty, but the second remains to be combated. To accomplish this, we must endeavor to recognize and remove the cause of the popular fallacy. Why is it that the victim of cancer confides the nature of the trouble to the physician with even greater reluctance than if it were syphilis or a venereal disease? From personal observation, I believe it is because the majority of patients are women. The greatest ambition of the average mother is that her daughters shall be happily and advantageously married, and believing that cancer is hereditary, she would rather suffer its pangs in silence than announce to the world a fact which would injure her daughter's matrimonial prospects. If a woman is driven by necessity to seek surgical relief, she enters a hospital with the greatest secrecy and confidence to the doctor under seal of professional confidence. If she is operated on and cured, no one ever knows the nature of her trouble. If she is operated on and there is a recurrence, she dies at home after a long and painful illness, the character of which eventually becomes widely known. The reason cancer is considered a disgrace is because of the belief in its tendency to develop in succeeding generations. The reason cancer is considered hopeless is that the cures are concealed and the failures revealed. The remedy is difficult, but must be found.

LECTURE XL.

MALIGNANT TUMORS (CONTINUED)—SARCOMA—DEFINITION, PATHOLOGY, VARIETIES, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT OF MALIGNANT TUMORS.

Sarcoma is a pathologic new growth composed of embryonal connective tissue cells, which tends to persist and to destroy its host by infiltrating surrounding tissues and organs, and by establishing metastases in other parts of the body, and by setting free toxic substances which produce a train of symptoms known as sarcoma cachexia.

The word sarcoma comes from a Greek word meaning flesh. To the naked eye, sarcoma, washed free of its blood, looks like eel's meat.

Pathology of Sarcoma. Sarcoma starts in connective tissue. The essential cell of sarcoma is the embryonal connective tissue cell. The nearer it approaches the adult type, the less malignant will be its course. Sarcoma cells are atypical in their relation to each other and to their intercellular substance, and also in their division or mitosis.

The stroma of sarcoma is usually scant and is at times difficult of demonstration. It may be a jelly-like substance, as in mucous tissue, or consist of fibers, as in fibrous tissue. It lies between the cells, binding them together, but separating one from the other as mortar does bricks in the wall of a house.

The Blood Supply of Sarcoma is usually abundant. The vessel walls are poorly developed and frequently consist of ill defined spaces or channels, with sarcoma cells for walls, so that the malignant cells can readily fall into the blood stream and be carried to all parts of the body. Sarcoma does not contain lymphatics.

The Course of Sarcoma. Sarcoma begins as a small proliferating area in some form of connective tissue, enlarges and invades surrounding tissues and organs. It is disseminated by way of the blood stream and not by lymphatics; hence its metastases may develop in widely separated parts of the body. The metastatic growths are identical in structure with the parent tumor. Sarcoma is subject to fibrous and myxomatous metamorphosis and to such degenerative changes as caseation, liquefaction and ulceration. When sarcoma has existed for a long time, or when its course has been very rapid, the same train of symptoms noted in cancer is inaugurated, and are known as the cachexia of sarcoma. Sarcoma kills by hemorrhage or exhaustion.

Location of Sarcoma. Sarcoma may occur wherever connective tissue is found—the true skin, submucosa of mucous membranes, bones, bone marrow and periosteum, intra-muscular connective tissue, the framework of glands, or in benign connective tissue tumors.

Varieties of Sarcoma. Adult or developed connective tissues are classified according to variations in the physical properties of their respective intercellular substances. Embryonal connective tissues have a scant, undifferentiated intercellular substance, but are far richer in cells than adult connective tissues. Hence a classification of tumors composed of embryonal connective tissue would of necessity be based primarily upon differences in its cells. The three principal varieties are therefore described as: (1) Round celled sarcoma; (2) Spindle celled sarcoma; and, (3) Giant celled sarcoma.

(1) *Round Celled Sarcoma* usually arises in fibro-elastic tissue, as the periosteum of bones, the framework of glands, the omentum, the subcutaneous connective tissue, etc. It is the most malignant of the three groups. It is composed of densely packed round cells, with very large nuclei occupying most of the cell. They have little or no stroma and progress rapidly, proliferation being most active near the blood vessels. When the cells are small, the tumor is called small round celled sarcoma; when large, it is called large round celled sarcoma. Extreme care must be exercised in differentiating small round celled sarcoma from inflammatory tissue. Sarcoma cells have relatively larger nuclei, which stain less intensely than the leucocytes. Atypical mitoses

are noted in the tumor cells, while cell division is not noted among the leucocytes. The blood vessels of sarcoma are characteristic in the absence of normal walls, with tumor cells often bordering their lumina.

(2) *Spindle Celled Sarcoma* arises also in fibro-elastic tissue oftener than elsewhere. It is less malignant in its course and less prone to form metastases than the round celled variety. It consists of masses of small or large spindle cells in a homogeneous or fibrillar stroma. It may be mistaken for leiomyoma or a new rapidly growing fibroma. The normal blood vessels in the benign growths are the chief diagnostic difference. The disposition of the spindles in sarcoma is also quite characteristic. In the myoma, there were noted bundles whose cells were parallel to one another. These bundles were irregularly placed in whorls and masses. In sarcoma, it is the cells that are irregularly disposed, without the characteristic arrangement in bundles.

(3) *Giant Celled Sarcoma* usually arises from the marrow cavity of bone. It is less rapid and less malignant than the round celled variety. In addition to other sarcoma cells, there are found large multi-nuclear cells like the giant cells of bone marrow. Spindle cells are commonly found with the giant cells, and always greatly outnumber the larger elements. A tumor of giant cells alone is unknown.

SUB-VARIETIES OF SARCOMA.

(*a*) *Mixed Cell Sarcoma* is a name given to a variety of tumor in which there is a mixture of two or more of the foregoing types of cells.

(*b*) *Alveolar Sarcoma* consists of groups or nests of cells embedded in a fibro-elastic stroma and resembling alveolar carcinoma.

(*c*) *Melano Sarcoma* is characterized by a peculiar black pigment called melanin in the tumor cells. They show early metastases and pursue a very malignant course.

(*d*) *Fibro Sarcoma* is characterized by a considerable matrix of intercellular fibers. Being an approach to the mature type, it is one of the less malignant varieties.

(*e*) *Myxo Sarcoma* has a matrix of mucous tissue. It is usually the result of retrograde metamorphosis, or else the tumor was originally a myxoma which underwent sarcomatous change.

(*f*) *Osteo Sarcoma* is a sarcoma affecting bone. The new growth is not new osseous tissue. The line of junction of the diaphysis and epiphysis in long bones is a favorite seat of this type of tumor.

(*g*) *Malignant Endothelioma* is a type of sarcoma arising in the endothelium of blood or lymph vessels, or in lymph spaces such as the perivascular or perineural lymph spaces. Those arising from blood vessels are called hemangio sarcomata; those arising from lymph vessels are called lymphangio sarcomata.

(*h*) *Malignant Lymphoma* or lympho sarcoma is sarcoma primarily affecting lymphatic tissue. It is a rare condition and a most malignant one. Lymphatic tissue is a mesodermic derivative and intimately related to the connective tissues; hence the designation of a new growth in lymphatic tissue as a sarcoma is in no way out of place. Microscopically, the growth consists of numbers of new cells so closely resembling lymphatic cells that a differential diagnosis from an inflammatory swelling of a lymph node is difficult, unless the capsule of the node has been ruptured and surrounding tissue invaded.

(*i*) *Glioma* is a malignant new growth classed clinically with sarcoma. It is composed of embryonic glia cells which are ectodermic derivatives, hence it is genetically not to be classed with connective tissue tumors. A glioma is found wherever neuroglia occurs, namely, in the brain, cord and retina. Microscopically it consists of small nucleated stellate elements with numerous fibril-like processes. Larger cells with several nuclei are occasionally found. It is an extremely malignant growth and by reason of its location in the cranium or spine gives rise to distressing pressure symptoms.

(*j*) *Hypernephroma* is a tumor made up of suprarenal tissue and while generally classified as a benign growth is now believed to be in most cases a clinical variety of sarcoma. There is a marked tendency to metastatis especially to the bones, brain and lungs by way of the venous channels.

Diagnosis of Sarcoma. This is based on the history of the case and the character of the growth. A hard, fixed tumor in a connective tissue structure, occurring in a young patient, should always arouse suspicion. If the growth has been rapid, if the superficial veins over it are dilated, if inflammatory symptoms are wanting, if syphilis and tuberculosis can be eliminated, and if the adjacent lymph nodes are unaffected, a specimen should be obtained for microscopic examination, if doubts as to its nature still exist. Swelling at the epiphyseal lines in the long bones should receive early careful examination. The X-ray is a valuable aid in showing invasion and destruction of bone and is a diagnostic agent of pronounced usefulness.

Prognosis of Sarcoma. The prognosis of sarcoma is even worse than that of carcinoma, due to the more rapid and widely disseminated systematic infection through the blood vessels as compared with that of carcinoma through the lymphatics. The prognosis is influenced, just as in cancer, by the character and location of the growth, the age of the patient, the stage of diagnosis, and the completeness of the operation.

Treatment of Malignant growths. The great importance of this subject can only be appreciated after taking into consideration, first, the frequency of the disease; second, the apparent rapid increase in the number of cases; and third, the improvement in results that has followed the modern method of radical surgical removal.

In England there are each year over 7,000 deaths from cancer and 30,000 patients are always under treatment. In the United States there are over 25,000 deaths annually, and it is believed that there are 100,000 people in this country now suffering from the disease.

Roswell Park makes the startling statement that if cancer continues to increase during the next ten years as it has done in the past ten years, at the end of a decade more people will die in the State of New York from cancer than will die from small-pox, typhoid fever and tuberculosis combined. It is but fair to state that Senn and others claim that this increase is more apparent than real, and is due to more accurate diagnosis, more frequent post-mortems, more general resort to operative intervention, and to increased longevity.

Statistics in regard to the improvement in the permanency of results of operations for cancer and sarcoma are prolific, but not easily concentrated to comparative figures. The value of statistics, too, is over-estimated, for they are necessarily "back numbers" and never keep pace with progress. Dennis has recently reported eighty-seven malignant growths operated upon and cured, the nature of the disease in each instance being demonstrated by microscopic examination, and the permanency of results tested by careful subsequent observations for a period, in no instance, less than three, and, in some, over twenty years. While Dennis' results are no better than those obtained by many other surgeons, still he deserves the thanks of the profession for the arduous labor he has performed in tracing his cases, and proving the unsoundness of the views of many who still claim that cancer and sarcoma are incurable.

In actual practice almost every conceivable treatment has been applied to malignant tumors, and while the dearly earned experience has united the profession in the conclusion that at the present time there is but one possibility of cure—namely, early and radical operation, still it will be well to review other methods which have been tried and failed.

Electricity. Electricity, which has promised so much in so many different fields of medicine, and which has yielded no little of practical, positive therapeutic value, has been long, faithfully and variously employed in the treatment of cancer. Constant and interrupted currents have been applied, and electrolysis and cataphoresis used, with negative results. The X-ray is now being extensively used, and while many enthusiasts report remarkable cures, it seems, at best, to have little influence on any except the most superficial growths.

Drugs. The local application of methylene blue, formaldehyde and similar antiseptics has resulted in no good except to diminish the offensiveness of discharge in ulcerative cases. The parenchymatous injection of alcohol, acetic acid and other sclerotics has accomplished nothing, save in a few cases where they have temporarily arrested the local extension by impairing the blood supply through cicatrization of adjacent tissues. The internal administration of iodide of potassium, arsenic, condurango, turpentine, cinnamon, clover tea and a host of others has served no purpose, unless it has been to keep alive the flickering hope of victims painfully conscious of their doom. The last exploded fad is the use of trypsin and amylopsin.

Toxins and Serums. The injection of the combined toxins of the streptococcus erysipelatis and of the bacillus prodigiosus, which for a time excited so much attention, has ceased to be seriously considered. Even its originator, Coley, states that it has only an inhibitory influence on carcinoma and is rarely curative. Cancroin, a toxic product derived from cancerous tissue by Adamkiewiez, has been extensively tried, but has proved to be without specific virtue. Blood serum obtained from horses, goats and sheep injected with cancer juice or the toxins of the supposed cancer protozoön, have likewise failed. Despite these facts, the serum therapy offers a promising and fascinating field for investigation. If malignant growths are due to a parasite, if they can be isolated and cultivated, if their peculiarities can be studied and their idiosyncrasies noted, in the words of Dr. Park: "It is not too much to hope that some agent, be it vegetable or mineral drug or animal antitoxin, may yet be discovered, by which the ravage of the disease may be checked or prevented."

Caustics. Chemical escharotics were once largely used by the profession in the treatment of superficial forms of malignant growths, but they have now been practically abandoned and are only of interest owing to their frequent revival by quacks and charlatans, who re-introduce them as new discoveries cloaked in mystery and invested in marvelous properties. A caustic causes coagulation of the protoplasm of the cells with which it comes in contact. It affects healthy and diseased tissue alike, as it acts chemically and has no selectivity. Its action is slow and painful, and the struction of tissue is uncertain in extent. It leaves an open, suppurating wound, which entails a long period of convalescence, with danger of hemorrhage and infection. Despite these facts, cancer quacks prosper because they apparently are not restrained by moral obligations or legal responsibility, and advertise in secular and religious papers, offering hope and promising cure to despairing wretches ready to grasp at straws. It is to be hoped that the public who support a Society for the Prevention of Cruelty to Animals, and the Legislature which has passed laws to prevent money being obtained under false pretenses, will shortly be aroused to their responsibility and correct the evil which is not appreciated until investigated.

Operative Treatment. The early radical use of the knife offers the only possible cure for carcinoma and sarcoma. The theory that these diseases are local manifestations of a constitutional dyscrasia has been abandoned, and the fact that both are at first a strictly local disease and become regional and general later by extension and metastasis, has been accepted. If the diagnosis is made early while the disease is yet local, if the location of the growth is such as to permit its complete removal, the prognosis is fairly good. If the diagnosis is delayed until the disease becomes regional or general, the prognosis is practically hopeless.

Second only in importance to early diagnosis is the completeness of the operation for the removal of infected tissue. Heidenheim, by exhaustive research, has shown the direction of regional extension of cancer and taught the surgeon the necessity of not only removing the organ in which the disease originated, but the adjacent lymphatics as well. In sarcoma the line of excision should be as wide as possible of the disease. The osteo sarcoma of an extremity amputation should be done, not through the shaft of the bone, but by disarticulation of the joint.

The operations for carcinoma and sarcoma vary so widely with different locations of the growth that they cannot here be described, but must be studied in operative surgery.

LECTURE XLI.

RETENTION CYSTS—DEFINITION, STRUCTURE, CAUSES, VARIETIES, SYMPTOMS, DIAGNOSIS, PROGNOSIS, TREATMENT.

A Retention Cyst is a swelling due to the retention in a preformed space of a normal secretion or excretion, the retention being due to obstruction of the normal outlet or failure of absorption in the case of a ductless gland. It must not be confused with swellings due to the collection of morbid products such as pus in preformed spaces. A Fallopian tube, an appendix or an antrum of Highmore filled with pus does not constitute a retention cyst, for the contents is not a normal secretion, but a morbid or abnormal product. A retention cyst must also be differentiated from an inflammatory swelling, due to the action of microbic or other irritants, such as occurs from effusion into a knee joint or pleural cavity, as in synovitis or hydrothorax; also from a tumor or neoplasm, the result of proliferation of pre-existing cells, such as cystoma, in which the cyst wall is a new growth, and the cyst contents also a new product.

STRUCTURE.

1. *Cyst Wall.* The cyst wall represents the organ or the duct affected. If the obstruction is located at the origin of the duct it will be composed of the organ itself; if it is located at some distance the duct will also become distended and form a portion of the wall. The amount of connective tissue in the cyst wall as compared with the normal structure of the part involved varies. If the obstruction is acute, there will be rapid dilatation, resulting in distention with thinning of the wall. If the obstruction occurs slowly the wall may become enormously thickened from

the formation of new connective tissue. The epithelial cells which line the cyst wall correspond in structure with the epithelial cells which normally line the obstructed space.

2. *Cyst Contents.* The cyst contents consist at first of the normal secretion or excretion of the gland. After a time it may be changed and altered so as to be unrecognizable from the admixture of mucus, blood or pus.

Causes. The essential cause is the mechanical obstruction to the outlet of an active gland. This may be due to:

1. Altered secretions, as when the bile in the gall bladder becomes so thick it cannot flow through the cystic duct.

2. Impaction of a stone, as when a urinary calculus becomes lodged in the ureter.

3. Flexion or twisting of a duct, as is seen in Dietel's crisis, the most prominent symptom of movable kidney.

4. Valvular obstruction from congenital deformity or the result of disease, as is seen in some cases of hydronephrosis.

5. Pressure on the duct causing its distortion, as is the case in retention of urine in the bladder from enlarged prostate.

6. Inflammation of the mucous lining of the duct, which may cause obstruction primarily by swelling sufficient to close its lumen, as seen in catarrhal jaundice, or secondarily by ulceration and the formation of a stricture, as is seen as a sequel of urethritis.

Symptoms. Swelling is a symptom common to all retention cysts and comes on slowly or quickly according to the degree of obstruction and the amount of secretion or excretion normally produced by the gland. A sebaceous cyst develops very slowly, while an acute obstruction of the pancreatic duct or of the ureter causes a rapid enlargement. Pain varies greatly in degree and character. A wen may exist for twenty years without pain, while an acute hydronephrosis or distension of the kidney will give rise to most agonizing pain. Fever, an evidence of sepsis, is common in certain varieties of retention cysts, due to the fact that the pre-existing spaces, which serve as their starting point, frequently contain in normal condition, pyogenic and other micro-organisms.

Prognosis. Prognosis as to life depends upon the importance of the organ affected and upon the development of complications. The involvement of a cutaneous or mucous gland entails no risk, while the sudden blocking of one or both ureters may cause rapid death. Secondary infection entails danger of septicemia and pyemia and rupture of a cyst of an abdominal organ often causes fatal peritonitis.

Treatment. The indications underlying the treatment of retention cysts are the same for all and consist of:

1. An effort to remove the cause of obstruction and re-establish the normal outlet. If the obstruction be due to swelling of the mucosa, as in catarrhal jaundice, the congestion should be relieved by purgatives and a bland diet. If the swelling be due to impaction of a stone, as in the case of lodgement of a renal calculus in the ureter, an operation should be performed and the stone removed.

2. The establishment of a new avenue for the escape of the retained fluid by the formation of an artificial fistula. If the obstruction be due to cancer of the liver obliterating the common duct, then a new exit for the bile should be given by anastomosing the gall-bladder to the duodenum. Or again, if the urinary bladder is converted into a retention cyst by an obstruction of the urethra and quick relief is demanded, an incision should be made for the formation of an artificial suprapubic opening.

3. The removal of the organ which has been converted into a retention cyst, which is usually the quickest and most certain way of correcting the trouble and should be adopted when feasible as in appendectomy for retention cyst of the appendix, cholecystectomy for hydrops of the gall-bladder, or nephrectomy for hydronephrosis of one kidney.

SPECIAL FORMS OF RETENTION CYSTS.

1. *Skin.* The skin contains sweat glands and sebaceous glands. Cysts of sweat glands are rare. The few cases on record have been located on the face in the vicinity of the ear. The cyst wall is extremely thin and delicate. Cysts of sebaceous glands, on the con-

trary, are extremely common and may occur on the skin at any part of the body, but their favorite location is the scalp. The comedo is the smallest and most superficial type and consists of a white enlargement the size of a pin head, with a black spot which represents the obstructed lumen of the duct. When forcibly squeezed, the contents will be extruded in a worm-like bolus capped with a black head. A milium is a small white spot, but slightly elevated above the level of the skin, which is a result of retained sebaceous material becoming inspissated and flattened into a scale. A wen, which is a type of the larger and deeper sebaceous cysts, frequently reach the size of a walnut. The cyst wall is white, thick and tough, and the cyst contents composed of a thick, greasy mass, like soft cream cheese, which has a very offensive odor. A sebaceous cyst may remain quiescent for years, but is always liable to become infected, break down and suppurate. To remove a sebaceous cyst anesthetize the skin with cocaine, make an incision directly into the cyst cavity squeeze out its contents and then grasp the cyst wall with forceps and by gentle traction free it from its attachments and remove it. Every particle of the wall should be gotten out, else a recurrence will certainly take place.

2. *Mucous Membrane.* As mucous membrane is bountifully supplied with mucous crypts or glands, it is frequently the site of retention cysts, which resemble the three forms of sebaceous cysts—namely, the comedo, the milium and the wen. They are found usually in the mucous membrane of the bladder, ureters and biliary ducts, in the intestinal canal, Fallopian tubes and uterus. When occurring on the cervix they are called follicles of Naboth. Occasionally Bartholin's, or the vulvo-vaginal glands are involved, and the swelling, located on the internal aspect of one of the labia majora, reaches the size of a walnut. The wall of mucous retention cysts is thin and delicate and the contents has the characteristics of ordinary mucus. In case of old cysts, the fluid becomes more or less serous and the condition is then called hydatid. The treatment consists in incision, evacuation of the cyst contents and dissection out of the cyst wall. If owing to adhesion from suppuration or other causes this is

impossible, the swelling should be freely opened and the cavity packed with gauze and kept open until it heals by granulation.

3. *Fallopian Tubes.* When both the fimbriated and uterine ends of the Fallopian tubes become occluded, there is no longer escape for the glandular secretion which is poured into them and they become distended with fluid. This condition is termed hydrosalpinx and is usually bi-lateral. By far the most frequent cause is infection and inflammation. If the fimbriated extremity of the tube is not completely closed there may be periodic escape of the fluid into the peritoneal cavity, causing recurrent attacks of pelvic peritonitis. The tube often becomes so distended as to look like a sausage. Often suppuration takes place, with the transformation of the serum into pus, when the condition is called pyosalpinx. The treatment of a retention cyst of the Fallopian tube may consist either in the so-called conservative method by which an effort is made to remove the obstruction and afford drainage, or by the more radical procedure of salpinectomy or the complete removal of the tube.

4. *Appendix.* The vermiform appendix frequently becomes converted into a retention cyst by obstruction to its lumen and the retention of its secretion. The obstruction is usually a cicatricial contraction near its cæcal termination, the result of ulceration from infection. Sometimes the appendix becomes distended until it is the size of a small egg. If the condition is neglected secondary infection will sooner or later take place, with suppuration and danger of peritonitis. The proper treatment consists in the removal of the appendix by an abdominal section.

5. *Kidneys.* Retention cysts may involve only a portion of the kidney or the entire organ. Cystic hydrops of the kidney results from obstruction of a uriniferous tubule. They are usually multiple; often bi-lateral; may be congenital, or develop after birth. Owing to the disease, a kidney may be practically destroyed and consist in nothing but a huge collection of small cysts. If a child be born alive with double cystic disease of the kidneys it usually shortly dies from uremia. If an adult develops the disease as a result of chronic interstitial nephritis, the case is hopeless. In rare instances, when only one kidney is involved,

nephrectomy or the removal of the organ is indicated. Hydronephrosis, or the conversion of the entire kidney into a retention cyst, is usually due to an obstruction of the ureter. The most frequent causes are impaction of a calculus, formation of a stricture, pressure on the ureter by a benign tumor or involvement of its walls by a malignant growth. The obstruction may be complete and persistent, or may be incomplete and remittent. If it remains for a long time unrelieved it will convert the whole kidney into a thin-walled retention cyst, the parenchyma being entirely destroyed from pressure. Hydronephrosis is likely to become the seat of secondary infection and the contents become converted into pus, when the condition is called pyonephrosis. The diagnosis of the condition is based on the history, the symptoms; the presence of a large, movable, fluctuating mass in the region of the kidney, and is confirmed by ureteral catheterization. The treatment consists of a lumbar incision, the delivery of the kidney through the wound, and either the removal of the obstruction and the drainage of the cysts, or the excision of the entire organ.

6. *Liver and Bile Tract.* Obstruction of a biliary radical sometimes results in the formation of a cyst in the substance of the liver as large as a walnut, filled with inspissated bile. Obstruction of the hepatic and common ducts causes moderate distention of the entire liver. but its conversion into a retention cyst, such as would occur in a kidney, is prevented by the absorption of the bile which is taken up by the blood and eliminated through the kidneys and skin. Obstruction to the cystic duct prevents the bile entering the gall-bladder or mucus escaping from it. The mucus soon becomes converted into a serous fluid and the condition constitutes hydrops of the gall-bladder. Infection may follow, with the conversion of the fluid into pus, and the disease is termed empyema of the gall-bladder. In hydrops the swelling may be so large the gall-bladder may be mistaken for a kidney or ovarian cyst.

The treatment for obstruction of the biliary ways consists in opening the abdomen and, if possible, removing the cause. If there be a stone in the hepatic or common duct, the duct should be incised, the calculus extracted and the gall-bladder drained. If there be irremedial obstruction of the common duct as from malignant involvement, then relief of symptoms and prolongation of life may be secured by anastomosing the gall-bladder to the duodenum, thus affording a new passage for bile from the liver to the bowel. If there is obstruction of the cystic duct and the conversion of the gall-bladder into a retention cyst, the hepatic and common duct being open, the best operation would be a cholecystectomy, it having been demonstrated that an individual can get along as well without the gall-bladder as he can without the appendix.

7. *Pancreas.* The pancreas is likely to be the seat of cystic swellings, the result of obstruction of the pancreatic duct or one of its branches. The contents of the cyst is at first the physiological secretion of the gland, which is later altered by the addition of blood or the products of degenerative and inflammatory processes. The size of the cyst varies. If the canal of Wirsung is obstructed it may be as big as a child's head. As the cyst grows the gland structure disappears. The causes of obstruction are: First, calculi, either of pancreatic or hepatic origin. Numerous cases are on record where a gallstone lodging at the ampulla of Vater has produced not only jaundice, but obstruction to the flow of the pancreatic fluid. Second, cicatricial contraction, the result of old inflammation, the obstruction being located either in pancreatic tissue or in the course of the pancreatic ducts. Third, displacement of the pancreas, which is likely to occur owing to its feeble attachments, from either a fall or the pressure of a neighboring growth. By the dislocation there is twisting or angulation of the ducts, producing obstruction. The diagnosis is based on the rapid formation of a swelling in the pancreatic region, attended by pain, impairment of digestion, rapid emaciation and sometimes the presence of fat in the stools. In some cases there is a characteristic discoloration of the skin. The treatment consists of an abdominal section and either the extirpation of the cyst or the evacuation of its contents, and drainage. As the pancreatic fluid is very irritating to the peritoneum, great care should be taken to prevent its contact with the abdominal contents.

8. *The Thyroid.* The thyroid gland is one of the ductless glands and may form a retention cyst, either from over-production of its products or the failure of the circulation to take them up. The capsule of the cyst is formed of pre-existing connective-tissue of the gland, and the cyst contents consists of thyroid juices. By coalescence of several cysts, there is often formed a mass that fluctuates distinctly. This condition constitutes what is commonly termed cystic goitre. The treatment by tapping and the injection of irritants is uncertain and dangerous. They should be removed by the operation of enucleation, which is described in all text books dealing with goitre.

9. *Ovary.* Retention cysts form in the ovary from failure of a Graafian follicle to rupture. They never attain a size larger than a walnut, although sometimes two or more coalesce to form a mass of larger size. The cyst wall is composed of ovarian structure and the cyst contents of a clear yellow or bloody serum. Retention cysts of the ovary must not be confused with ovarian cystomata, which are true tumors. The treatment consists either in enucleation of the cyst or the removal of the entire ovary.

10. *Testicle.* Obstruction of a spermatic tubule results in the formation of a retention cyst which may occur singly or in groups. They usually occur just above the epididymis, but may be found in any part of the spermatic cord. The wall of the cyst is composed of connective tissue, and the contents is a fluid, which at one time contains spermatozoa. They grow slowly and rarely attain large size, although one case is reported where in a man 70 years old, there were 18 ounces of fluid. The treatment consists in excising the sac or draining.

11. *Mammary Glands.* Obstruction of a milk duct during lactation results in the formation of a retention cyst which is called a galactocele. At first the contents is milk, but if the condition continues it is substituted by a serous fluid, often stained with blood. Sometimes there are multiple cysts appearing simultaneously or in succession, either communicating or being independent one of the other. The cause of the condition is injury or inflammation, producing obstruction. The treatment consists in incision, drainage, and in bad cases, partial or complete removal of the breast.

12. *Salivary Glands.* A retention cyst of the sublingual or submaxillary gland is called a ranula. They are due to obstruction to the outlets of the glands, thc wall consisting of pre-existing tissue and the fluid at first of normal saliva. They frequently reach the size of a walnut and interfere with the movement of the tongue. The treatment consists either in excision, or when this is not possible, in opening, curetting and packing, the gauze being changed daily until the cavity fills in with granulation tissue.

LECTURE XLII.

WOUNDS—DEFINITION, VARIETIES, PATHOLOGY, SYMPTOMS, COMPLICATIONS, DIAGNOSIS, PROGNOSIS, AND TREATMENT.

A wound may be defined as a sudden solution of the continuity of soft tissues. This definition does not include fractures, because bone is not a soft tissue. An ulcer is also not considered a wound because it is the result of slow disintegration and not sudden solution of tissue. It is unnecessary to impress the frequency and importance of wounds, as they are both self-evident even to the laity.

VARIETIES.

Wounds are divided into accidental and operative wounds, open and subcutaneous wounds, aseptic and septic wounds; and into incised, lacerated, contused, punctured, penetrating, and perforating wounds, and wounds caused by special agents, such as arrows, bullets, snake bites, etc.

Accidental wounds are injuries inflicted by unexpected violence; operative wounds are incisions made after careful consideration to relieve pain, remove deformity, or save life. Open wounds are those in which there is a breach in the skin or mucous membrane exposing the underlying tissues to the air. Subcutaneous wounds are injuries to the deep structures, such as muscle or tendon, unattended by breach of the skin or mucous membrane. Aseptic wounds are injuries uncomplicated by infection, which, therefore, heal by primary union; septic wounds are injuries which, at the time of infliction or afterwards, become infected with pyogenic germs with consequent inflammation and suppuration. Incised, lacerated, and contused wounds are wounds presenting peculiarities owing to the nature of the instrument inflicting them. Bullet wounds, snake bites, etc., are placed in yet another class for reasons which will afterwards be made apparent.

PATHOLOGY.

The pathology in a general way is the same in all wounds, though there are differences in degree and differences due to the special structures involved. In every wound there is death or destruction of cells, the number killed depending on the severity of the injury and the nature of the vulnerating body. Thus, for example, in a wound made by a sharp knife, only those cells traversed by the instrument die, whereas in the case of a wound made by a blunt force the death of cells is much more extensive. The process of healing is also the same in all cases; the dead cells are absorbed or thrown off and regeneration takes place through the process of granulation, vascularization, cicatrization, and epidermization, as described in a previous lecture.

SYMPTOMS.

The local symptoms of a wound are pain, hemorrhage, gaping, and impairment of function.

1. *Pain.* The character and intensity of pain varies with the cause, anatomic position, and susceptibility of the individual. A wound made by a sharp knife causes an immediate, sharp, stinging pain which lasts a few hours and then subsides, while one made by a dull, blunt instrument is often not appreciated at the time, the pain coming on slowly and gradually increasing in intensity. Injuries to some tissues cause more pain than to others, for example, a wound on the finger is very distinctly more painful than one of corresponding severity on the back. Nervous, debilitated individuals often suffer more pain from a trivial injury than a robust phlegmatic person does from one even more severe. The same individual may suffer more on some occasions than others. It is said that pain is less severe after a full meal than when the patient is hungry.

2. *Hemorrhage* is also a variable symptom and depends on the character of the instrument inflicting the wound, the anatomical location of the injury and the constitution of the individual. Incised wounds bleed immediately and freely; lacerated and con-

tused wounds bleed little at first but copious hemorrhage may occur later. Wounds of the scalp and face bleed freely on account of the vascularity of the tissue, while incisions at other parts of the body less abundantly supplied with vessels do not bleed as much. Wounds on the plethoric, or full blooded, bleed more copiously than those of the anæmic. Hemorrhage is spoken of as arterial, venous, or capillary. If an artery is cut, we have arterial hemorrhage. The blood is a bright scarlet in color and comes in spurts. If a vein is cut we have venous hemorrhage. The blood is dark blue in color and wells up in a slow and steady stream. If only the capillaries are divided, the blood is red and comes to the surface in small drops like sweat. When hemorrhage occurs at the time the wound is inflicted it is called primary hemorrhage; when it occurs after the primary hemorrhage has ceased, but before the expiration of forty-eight hours, it is called intermediary hemorrhage; when it occurs after the fifth day it is called secondary hemorrhage.

3. *Gaping*, or retraction of the edges of the wound, is a result of the elasticity of the tissues and is a fortunate provision, since it secures drainage and prevents the collection of fluid. The amount of gaping depends on the structures divided and the line of the division. The skin is very elastic and retracts most markedly. A wound transverse to the fibres of a muscle gapes more than one parallel with its fibres.

4. *Impairment of Function*, or the disability of the part injured to do its accustomed work, is a result of pain together with mechanical injury and is another effort of Nature to favor regeneration by putting the part at rest.

COMPLICATIONS.

Complications developing after an accidental or operative wound may be divided into local and constitutional.

1. *Local.* Perhaps the most common local complication is *inflammation.* This is not a natural sequence but is due to infection, the part becoming red, swollen, hot and edematous. The treatment consists in the use of proper aseptic and antiseptic

means to prevent infection, and in the measures previously described in the lecture on inflammation, to relieve the symptoms after they develop. Another complication is *suppuration* or the formation of pus, and its prevention and cure should be carried out along the lines previously laid down. Occasionally *gangrene* occurs in the wound, either as a consequence of suppuration or as a result of obstruction to the blood supply of the part. Finally, *erysipelas* may result. This was formerly more common than at present. It is still seen in accidental wounds, although its occurrence in intentional wounds is a serious reflection on surgical technique.

2. *Constitutional.* Shock is the most common. It varies in degree with the nature and severity of the injury and the part affected. It is always present after mutilating accidents, especially if attended by much loss of blood, but is not usually seen in marked degree after operations performed on properly prepared patients, when there has been no unnecessary loss of heat, blood, and time. The symptoms consist of a rapid and irregular pulse, shallow, sighing respiration, subnormal temperature, cold and clammy skin, pale, pinched face, and apathy of the mental faculties. The treatment when the condition is present consists in perfect quite, application of external heat, elevation of the foot of the bed, and the administration of a small dose of morphine. In cases of accidental injury, unless complicated by hemorrhage, an operation should be postponed until after reaction.

Traumatic Delirium is sometimes seen as a complication after injuries to the head, the chest, the genital organs, and sometimes, in nervous individuals, as a result of severe and prolonged pain. There is no fever, but the patient is delirious, mutters to himself, tosses about the bed, and, for days, knows nothing of his condition. The pathology of this condition is not known and it should be treated purely symptomatically. As a rule the patient recovers.

Delirium Tremens is a complication always to be watched for after injuries or operations on patients addicted to alcohol. It is more common in those who drink steadily, although never drunk, than after periodic debauches. There are some people who boast that they were never drunk in their lives but who are to a certain degree continuously under the influence of whiskey. They are often regular and industrious in their work, and their addiction to drink may not be known outside of their immediate family. When a man of this character receives a fracture or is operated on for some chronic ailment, he frequently develops delirium tremens. He becomes restless and tremulous, is unable to sleep, picks at the bed clothes and begins to have hallucinations. He will answer questions intelligently, but even while talking, will brush hypothetical lice from the bed clothes or gaze fixedly at an imaginary angel or harlot at the bed post. In bad cases, the patient is insensible to pain and has to be carefully watched, as he will remove splints and attempt to walk on a broken leg. Not infrequently such patients have been known to leave the house in inclement weather, scantily clothed, in an effort to escape the persecution of their hallucinations. The preventive treatment of delirium tremens consists in the continuation of alcohol after accidental injuries and the withdrawal of of alcohol for some days prior to a premeditated operation. When the condition develops, it is better in some cases to give full doses of whiskey at first, and gradually reduce the quantity; in others it will be found best to at once discontinue the stimulant. Insomnia is a symptom most difficult to relieve. If the patient can be made to sleep he will recover; if his brain cannot be given rest he will die. The drugs employed are morphine, chloral and bromide.

Fat Embolism is a rather uncommon complication, but is sometimes seen, especially after fractures or other traumatisms, causing injury to adipose tissue. The fat from the medullary cavity or other locality undergoes disintegration and partial liquefaction, enters some vein and reaches the heart. It is pumped into the lungs, where it lodges, producing fat embolism. This complication when it occurs, usually results from twenty-four to forty-eight hours after the injury. Up to this time the patient may have been doing well. Suddenly there is profound depression, rapid and feeble pulse, irregular respiration, marked dyspnœa and cyanosis. The patient sits up in bed, gasps once or twice, and falls back dead, or, if the embolus is small, the symptoms may not be so alarming and recovery ensue. If this be the case, fat globules will be found in the urine. The prevention of fat embolus consists in the proper immobiliation immediately after the fracture, and in carefully avoiding unnecessary injury to fatty structures during the course of an operation. When there is any reason to expect the complication, it may be averted by the use of drainage, which will relieve tension and prevent the liquefied fat being forced into the circulation.

Among other constitutional complications which might be described are *septicemia, pyemia* and *lock-jaw.* Their causes, symptoms and treatment have already been described in previous lectures, hence they will not be discussed again.

TREATMENT OF WOUNDS.

1. *Arrest Hemorrhage.* The first duty of the surgeon after an injury is to stop bleeding and this should be done by the simplest method that will prove efficient. Never apply heroic measures unless absolutely necessary, as they retard healing and predispose to infection. Often, moderate bleeding can be stopped simply by elevating the part, thus by gravity diminishing the force of the arterial blood and favoring the venous return. In many instances the temporary use of pressure will be all that will be required for the arrest of hemorrhage. This may be most efficiently applied in the form of gauze compresses, wrung out of water as hot as can be borne by the hand. Cold is sometimes employed, but is not to be recommended, as it lessens the vitality of the tissues. If elevation, pressure and heat are not sufficient to meet the requirements, then ligation of the bleeding points must be practiced, the arteries or veins being caught with hemostatic forceps, and tied with fine aseptic ligatures. In times past, surgeons have used astringent or escharotic agents to stop bleeding, such as turpentine, Monsel's solution of iron, or the actual cautery. These cause coagulation of the blood, but while efficient

at the time, eventually result in necrosis of tissue, which delays union and is usually followed by suppuration. Adrenalin solution is a safe, and sometimes satisfactory, substitute for the above but usually where there is persistent oozing, it is better to pack the wound with gauze and wait for twenty-four hours before bringing together its edges.

2. *Secure Asepsis.* In an accidental wound, great care should be taken to remove from it blood clots, devitalized tissue and foreign bodies, such as pieces of cloth or fragments of glass. After this has been done, the wound should be disinfected to free it of organisms which might cause putrefaction or suppuration. The means to be employed depend upon the nature of the injury, and require considerable judgment. It must be remembered that germicidal solutions not only kill germs, but coagulate protoplasm and destroy tissue cells. Very often wounds do badly, not on account of germs which have been introduced by the accident, but on account of the natural resisting powers of the tissues having been removed by the surgeon. Strong and irritating antiseptic solutions should, as a rule, be avoided. In cases where there has been manifestly severe infection, the wound should be left open and lightly packed with iodoform gauze.

3. *Effect Accurate Coaptation.* After arresting hemorrhage and securing asepsis, the next effort of the surgeon should be to bring the surfaces of the wound into coaptation, so the divided parts will occupy the same relation to each other as existed before the wound was inflicted—*i. e.*, muscle to muscle, fascia to fascia, and skin to skin. In a trivial wound, coaptation may be effected by fibers of cotton soaked in collodion, or strips of aseptic adhesive plaster, placed across the incision. In wounds of greater magnitude, sutures will have to be employed.

Stitches may be buried or superficial. They may be stitches of coaptation, stitches of approximation, or stitches of relaxation. They must be so placed as to avoid leaving dead spaces in which serum or blood would collect, and they must be so tied as to bring the parts together without tension. A tight stitch causes necrosis and frequently leads to suppuration. In hospital practice, when a clean wound suppurates, the surgeon usually charges it to faulty sterilization on the part of the nurse, when often it is the result of tissue strangulation from over-taut ligatures.

4. *Provide for Drainage.* In securing coaptation of a wound, the surgeon must bear in mind the possibility of oozing or of pus formation, and if either seems likely to occur, to leave an avenue for their escape—in other words, to provide drainage. In some cases this can best be done by inserting the sutures, but not tying the most dependent, for twelve or twenty-four hours. Again, a tubular or capillary drain may be inserted and brought out between the stitches. And lastly (and this is usually the best practice), a separate stab wound may be made, through which the drain is inserted, and the primary wound completely sutured. A gauze drain acts by capillarity; a tubular drain acts by gravity. They may be combined in a happy manner by splitting a rubber tube lengthwise and laying in its lumen a strip of gauze. The objection to a drain is that it delays the union of the wound; that it adds to the danger of infection, and that in certain locations it predisposes to hernia. In many cases, however, these are an unavoidable evil. A drain should be removed as soon as it ceases to perform its function, which is usually within from twenty-four to forty-eight hours.

5. *Apply a Protective Dressing.* After fulfilling the foregoing indications, the wound should be dressed. The object of applying a dressing is twofold—to absorb secretions that may come from within, and to prevent infection and injury that may come from without. The materials used are commonly gauze and cotton. In clean wounds they simply need to be made aseptic by sterilization. In septic wounds, they should be made antiseptic by being impregnated with iodoform, carbolic acid, or bichloride of mercury. A wound should not be dressed oftener than necessary. The indications to change a dressing are pain, fever, or the saturation of the dressing with wound secretion. If none of these occur, the dressing should be left untouched until the drain or the stitches have to be removed. In changing a dressing, the laws of asepsis should be carefully observed.

6. *Maintain Physiologic Rest.* During the process of healing, a wound should be kept at perfect rest. If the injury or operation is one of severity, the patient should be confined to bed. In many cases, if the wound be of an extremity, additional immobilization by means of a splint is advisable. If the injury be to the bowel, rest is secured by starvation; if the injury be to the eye, a shade should be worn and light excluded from the room; if the injury be to the bladder, the organ should be relieved of its function, by the use of a permanent catheter, etc.

7. *Constitutional Treatment.* Pain should be made bearable by the use of small doses of morphine, administered hypodermically. Mental depression should be combated by a cheerful mien and hopeful prognosis. The general comfort and health of the patient should be watched, and complications carefully guarded against. The bowels should be kept open, the appetite stimulated, the number of visitors regulated, and the nursing and the hygiene of the sick room watchfully supervised. The quantity, quality and variety of food is also a matter of much importance.

LECTURE XLIII.

WOUNDS (CONTINUED)—INCISED, LACERATED, PUNCTURED AND GUNSHOT WOUNDS—THEIR CAUSES, SYMPTOMS, DIAGNOSIS, PROGNOSIS AND TREATMENT.

INCISED WOUNDS.

An incised wound is a wound made by an instrument possessing a sharp, smooth cutting edge, and is characterized by the fact that only the cells directly in the path of the instrument are killed. Such wounds, under proper treatment, will heal within a few days by primary union.

Causes. Incised wounds are inflicted accidentally with a sword, knife, hatchet, or broken glass, and intentionally by the surgeon with the scalpel or scissors.

Symptoms. Pain, is severe and cutting in character being felt immediately after the injury and subsiding in a few hours, unless infection occurs. Hemorrhage is profuse on account of the vessels being cleanly divided, the quantity of blood lost depending on the region involved and the size of the vessel cut. Gaping, or the separation of the edges of the wound, is limited only by the contractility and elasticity of the tissue involved.

Treatment. Arrest hemorrhage by pressure, elevation and hot applications. If these fail, use torsion or ligate the vessels. Never use styptics, such as Monsel's solution, as they coagulate albumen, destroy tissue cells and retard healing. Secure asepsis by washing the wound and surrounding skin with green soap and warm water and irrigating with a mild solution of bicholride of mercury. Examine the wound carefully to see if a nerve, tendon or muscle is divided, and if such injury is discovered, suture at once. Approximate the surfaces of the wound and maintain apposition by cotton wet with collodion, aseptic adhesive plaster or sutures. Drainage is not usually necessary in these wounds. Occasionally, however, it may be safer to put a small wick of gauze in the most dependent angle. This should be removed in twenty-four hours. Apply a dressing of gauze or cotton and retain it in place with strips of adhesive plaster or a bandage. Unless one of the three indications for an early change of the dressing occurs, viz: pain, fever, or saturation with wound secretion, it should be left undisturbed until the seventh or eighth day, when it is taken off, the stitches removed, and another dressing applied.

LACERATED AND CONTUSED WOUNDS.

A lacerated wound is caused by a tearing force; a contused wound is caused by a crushing force. It is, therefore evident that these two varieties of wounds are commonly combined, as an injury which causes laceration, at the same time results in crushing. The essential characteristic of these wounds is the extensive destruction of tissue. Cells distant from the point of application of the force are devitalized, resulting in necrosis and rendering it impossible for the wound to heal by primary union. In lacerated and contused wounds, the skin is badly mangled and the underlying structures are either pulpified and killed or else have their blood supply so impaired as to ultimately lead to necrosis. Trophic nerves and nutrient vessels are always damaged. Such wounds, therefore, are apt to slough, frequently suppurate, and are occasionally followed by cellulitis and by gangrene.

Causes. Lacerated and contused wounds may be caused by impact of any blunt body. They are usually seen as the result of rapidly moving and heavy vehicles, or as the result of accidents connected with modern machinery.

Symptoms. The surface of the wound is irregular, shreddy and presents long, dangling strips of connective tissue, with more or less blood clot filling interspaces. In many instances it has dirt of every conceivable character ground into it. Pain is sometimes entirely absent, the severe injury obtunding the sensory nerves, but later excruciating pain may result. Hemorrhage at first is not, as a rule, great, although large vessels may have been divided.

This is due to feeble heart action from syncope; to the mechanical closure of the vessels from the pressure of the force causing the wound, and to the rapid coagulation of the blood from its contact with ragged tissue. Serious hemorrhage may occur later, however, after reaction takes place, or after the separation of sloughs. Shock is always present in wounds of this character, the degree varying from a trivial form, such as results from a blow on the finger with a hammer, to a fatal form, such as is sometimes reported after the evulsion of a limb.

Treatment. Although hemorrhage is usually trifling at the time of the injury, it is the surgeon's first duty to ligate the visible vessels. During reaction from shock, the wound should be carefully watched, for sudden or unexpected bleeding may occur. Shock, if present in a marked degree, should be combated in the usual way, although care should be taken not to cause too rapid reaction by over-stimulation. All lacerated and contused wounds should be regarded as infected wounds, and the most difficult and important task is that of disinfection. All foreign particles, such as pieces of clothing, cinders, gravel, etc., should be removed with forceps. If the part be contaminated with greases from machinery, it is best removed with sweet oil, followed by scrubbing with green soap and hot water. Finally, the wound and surrounding area should be irrigated with bichloride or carbolic acid solution, and then dried with sterile gauze. Devitalized tissue should be cut away; doubtful tissue left in place. Although drainage of these wounds is essential, artificial provision for it is not usually necessary, as the surface is left open, no effort, as a rule, being made to bring the skin edges together. Usually the best dressing is a hot, antiseptic fomentation, made by soaking a thick pad of cotton in a warm solution of 0.5 per cent chloral hydrate or a 2 per cent boracic acid solution applying to the part and covering with oiled silk to prevent escape of heat and evaporation of moisture. This dressing should be changed as frequently as it becomes soiled. Under this treatment, sloughs will rapidly separate and soon a healthy granulating surface result. Epidermization may then be hastened by one of the various methods of skin grafting, or by the use of some of the ingenious plastic methods by which flaps from the margin are thrown over the denuded area.

PUNCTURED WOUNDS.

Punctured wounds are caused by pointed instruments and partake either of the nature of incised wounds or of contused and lacerated wounds, according to the nature of the vulnerating body.

Causes. Needles, pins, daggers and stilettos make sharp, clean punctured wounds, while rusty nails, splinters of wood, or fence palings make contused and lacerated punctured wounds.

Symptoms. When the instrument inflicting the wound is withdrawn, the tissues contract, blood and other fluids cannot find exit, and the external appearance gives little or no evidence of the extent of the injury. The amount of pain depends on the nature of the instrument inflicting the wound. If produced by a smooth, cutting instrument, it is considerable, but if produced by a dull, bruising instrument, it is not so severe. The degree of shock experienced will depend not only on the nature of the instrument, but also on the anatomical part involved. If a cavity is entered, such as the abdomen, the wound is said to be a penetrating wound; if the instrument passes through the cavity and appears on the opposite side, it is said to be a perforating wound. External hemorrhage is usually slight, although a large blood vessel may be injured and considerable internal bleeding result.

Treatment. This depends upon the nature of the instrument inflicting the wound and the anatomic structures through which it passes. A punctured wound made by a clean, sharp instrument, not involving any important organ, cavity or blood vessel, demands only external disinfection and an occlusive dressing. A wound made by a rough dirty instrument, such as a rusty nail or a splinter, demands free incision so as to expose its track to the bottom, thorough disinfection and drainage. A neglect of this will not only lead to destructive inflammation, but, in a certain percentage of cases, to the development of tetanus. When, owing to the location and direction of the wound, as a punctured wound of the abdomen, it is thought an important organ may have been injured, it is wise to make an exploratory incision for the purpose of diagnosis and for necessary correction of the damage.

GUNSHOT WOUNDS.

Gunshot wounds are caused by missiles that have been projected by force derived from explosives. They have the characteristics both of penetrating and lacerated wounds.

Causes. The causes are missiles from the smallest bird shot to the mammoth shells. Occasionally the injury may be inflicted by unburnt powder, wadding, fragments of metal or pieces of stone. A gunshot at close range makes a wound similar to that of a pistol. Shot varies in weight from birdshot, one-fifth grain, to buckshot, 133 grains. A pistol ball varies from one-fifth to one-half inch in diameter. They are usually designated according to the decimal part of an inch; thus, a pistol termed a 32 caliber has a ball whose diameter is .32 of an inch. A rifle ball varies in size from the old conical minie ball, which weighed an ounce, to the modern steel-jacketed projectile of 30 caliber. The old Springfield musket had an effective range of only 200 to 300 yards, while the modern rifle has a range of from one to two miles. The bullet of the former was soft, readily flattened, and usually lodged in the individual wounded, while the bullet of the latter, owing to its hardness and the velocity with which it is driven, does not undergo deformation and usually penetrates and perforates its victim, pulpifying organs such as the liver and kidney, and extensively shattering bones.

Gunshot Wounds Occurring in Civil Life. Wounds from blank cartridges occur only at close range and are usually received in the palm of the hand. A cheap toy pistol is hard to cock, and a boy often places the muzzle against the palm of the left hand while he attempts to raise or lower the hammer with the right thumb. The injury consists of a combination of a burn and a laceration. Tetanus is extremely liable to result, as blank cartridges, in order to be made economically, are often wadded with infected clay. Wounds from shotguns vary in character, according to the distance of the individual from the gun when the discharge takes place. At short range the shot may strike as a solid body, carrying clothing and other foreign material into the tissue. At greater distance, the shot will have separated, each missile inflicting a separate wound. Wounds from pistols vary with the shape and size of the ball and the effectiveness of the weapon. Round bullets produce ecchymosis at the point of entrance, lacerating the tissue, and having little penetrating power. A conical bullet makes a cleaner wound of entrance, and if it perforates, leaves a large wound of exit. A cheap pistol fired at close range frequently inflicts only trifling damage, while a high-grade weapon, with the same ammunition, would cause a fatal injury.

Gunshot Wounds Occurring in Military Life. The modern army rifle, with smokeless powder and a jacketed bullet of .30 caliber, has a penetration across the grain of oak of about twenty inches. This projection produces explosive effect at a range of within five hundred yards, and upon the skull at thirteen hundred yards, and upon the liver, spleen, kidneys and hollow viscera at even greater distance. A bone, when struck within five hundred yards, is badly shattered. At fifteen hundred to twenty hundred yards, it is not usually comminuted, but cleanly perforated. At the usual range of modern warfare, it is extraordinary how little trouble follows a wound made by the military rifle, and how quickly healing occurs. This is due to the fact that, owing to its great velocity, the bullet becomes heated, so as not only to be itself sterile, but to actually sterilize the clothing, skin, etc., through which it passes. Moreover, on account of its small caliber, high density and great velocity, it does not carry foreign bodies with it. In a sense, it has very properly been termed a "humane weapon." The wound of entrance is small, and, in many cases, may be overlooked. It is usually circular, but may be triangular. The wound of exit is also small, and may be round, or a mere slit; it is always larger than the wound of entrance. This is due partially to the diminished velocity of the ball, but principally to the fact that the skin at the point of exit is not supported. The modern bullet cuts, and does not push aside, vessels, hence primary hemorrhage is profuse if a large artery lies in its path. The opening it makes in fascia is small and the connective tissue fibers often contract so as to prevent drainage and interfere with the introduction of a probe. Muscles, when struck, are usually contused and pulpified. Tendons, owing to their mobility, are often pushed aside and escape division. Nerves are usually cut. Bones are either perforated or splintered into fragments. Penetrating wounds of the abdomen are usually complicated by injury to the stomach, intestines or other viscera.

Symptoms. Pain from gunshot wounds is variable. Men in the excitement of battle have been shot without knowing it. Policemen and other officers of the law have been known to continue the chase of a thief after being shot through the abdomen. A gallant Confederate general had his tibial artery cut by a ball during a charge, and was unconscious of it until he was told by a soldier that his boot was running over with blood. On the other hand, a gunshot injury may cause great pain. Men of unquestioned courage have been known to roll in agony after merely being grazed by a shot. Old soldiers tell us that when they were struck, it felt as if it were a blow with an axe. The amount of the hemorrhage depends upon the size of the blood vessel injured and upon the nature of the bullet. It is greater in wounds caused by a conical bullet than in those produced by a round bullet. Sometimes bleeding is trifling at first and becomes profuse later, either as the result of the reaction from shock or of the disintegration of the walls of a contused vessel. Shock after a gunshot wound is usually severe, especially in the case of a soldier who has been fighting all day without food or drink. The mental condition of the individual also influences it, as it is a well-known fact that the victorious soldier suffers less shock than does his defeated antagonist, from an injury of the same degree and character. Thirst is an invariable symptom following a gunshot wound, and is so great that it cannot be explained as due either to hemorrhage or shock.

Diagnosis. This is based on the history of the injury and the nature of the wound. In endeavoring to determine the extent of damage, it is a good plan to place the parts in the position they were in when the injury was inflicted. If possible the nature of the weapon, the direction and distance at which it was fired, should be ascertained. The clothing should be examined to see if any fragments are missing that may have been carried into the wound. If the bullet has not perforated, but has lodged in the tissue, it is a great temptation to insert a probe in order to locate it. It has been said that "the life of a man injured by a bullet is in the hands of the doctor who first attends him," and the probe has been called "an instrument of the devil." These facts should be remembered, and if the probe is used, it should be done under the most rigid antiseptic precautions. As a rule, it is better to let the bullet alone until it can be located by the use of X-ray.

Prognosis. This depends upon the nature of the injury and the symptoms present. Apart from the mechanical injury inflicted, the chief dangers are shock, hemorrhage and infection.

Treatment. Gunshot wounds usually occur in bar-room fights, street brawls, in the hunting field, or on battle-grounds. They are emergency cases and usually have to be treated without the aid of skilled assistance or hospital accessories. The treatment applied must be divided into two stages, the first consisting in what is done at place of accident; the second in what is done after the removal of the victim to a house or hospital. The indications of the treatment in the first stage are to stop hemorrhage, relieve pain and combat shock. Hemorrhage is best arrested by direct pressure or the use of a tourniquet. Pain, if excessive, is relieved by the hypodermic administration of morphine, and shock is combated by lowering the individual's head, the application of external heat, and the administration of moderate doses of strychnine and whiskey. The wound should not be probed, for, under the surroundings, asepsis is impossible. If antiseptic dressings are at hand, they should be applied, but if not obtainable, it is better to leave the wound exposed to the air than to contaminate it by the use of septic materials, such as handkerchiefs or underwear.

As soon as possible, the patient should be transported to a hospital, where the second stage of treatment is carried out. This will depend entirely upon the nature of the injury and the complications which are present. In many cases, practically nothing further is necessary except the external disinfection of the wound or wounds, the application of dressings, and the rest of the part by either the use of immobilizing apparatus or confinement to bed. Unless there is some indication, it is a mistake to attempt to remove the bullet. Most bullets are aseptic, and unless the wound becomes infected, they will give no trouble. Wounds of the abdomen, brain and thorax generally call for an exploratory operation, in order to detect and correct the damage done to internal organs. Amputation may sometimes be demanded because of injury to the bone, joint or large vessels or nerves.

What has been said, however, does not apply to wounds inflicted by toy pistols. These must, in every case, be regarded as infected by the bacillus of tetanus, be heroically disinfected, opened and drained to the bottom, and the victim given prophylactic doses of the antitoxin of tetanus.

LECTURE XLIV.

WOUNDS (CONTINUED)—ARROW WOUNDS—BRUSH BURNS—DISSECTING WOUNDS—STINGS OF INSECTS—BITES OF SERPENTS.

ARROW WOUNDS.

Arrow wounds are wounds inflicted by arrows. They present the features both of a punctured and a contused wound. At the present time they are so rare that they do not require much consideration. They are practically met with only by the military surgeon or explorer in uncivilized countries. An arrow consists of a feathered shaft, tipped with a head of stone or metal. The head is usually fastened to the shaft by a leather thong. An arrow head, unlike a bullet, will not become encapsulated, and if allowed to remain in tissue will invariably produce suppuration; therefore, it is always essential to remove it. This is sometimes an operation of difficulty, as the barbed head becomes entangled in tissue and cannot be withdrawn. If the shaft of the arrow is attached to the head it should never be pulled upon, but should be used as a guide for dissection and exposure of the head. Sometimes, if the arrow has almost perforated a limb, it is better to push it on and remove it through a counter incision. The wound should be regarded as an infected wound and should always be disinfected and drained.

BRUSH BURNS.

Brush burns are superficial abrasions and contusions caused by friction applied to the surface of the body. They are characterized pathologically by a brushing away of the superficial tissues, with eschar formation of the deeper structures. There is little or no hemorrhage. Pain is usually immediate and intense. Later the eschar sloughs, leaving a raw surface which heals slowly.

Causes. A brush burn may be produced by contact of the body with a rapidly-moving object, such as a revolving grindstone or driving belt of a machine, or again, by the body of the individual moving rapidly and coming with friction against a stationary object, as when an individual involuntarily slides down a steep incline or has a rope slipped through the closed hand.

Treatment. From the nature of the wound, no effort to close it is feasible. The raw and oozing surface should be washed with a mild antiseptic solution and protected by moist, absorbent dressings. After the devitalized tissue separates and a healthy granular surface results, it should be treated on the same principles as loss of cutaneous covering from any other cause.

DISSECTION WOUNDS.

Dissection wounds are wounds complicated by the introduction into the system of septic material from putrefying organic matter. They occur chiefly in surgeons and students and in those who conduct post-mortem examinations. They are occasionally seen in cooks, butchers and fishmongers, who handle putrefying organic substances. They are simply examples of infected wounds and present nothing peculiar except great virulence.

Causes. The exact nature of the poison is unknown. A dissection wound inflicted while working on a body injected with chloride of zinc does not often give trouble. A wound sustained in making a post-mortem, especially on a subject who has recently died from some septic process, such as puerperal fever, pyemia or erysipelas, is especially dangerous. Not only is the result of inoculation dependent upon the nature of the poison, but it is also largely influenced by the general health and local resistance of the individual affected. It is a well-known fact that students fresh from their summer vacation are rarely the victims of serious infection, whereas, in the spring, owing to lowered vitality from confinement and improper food, they are susceptible and frequently develop the condition. In every case of a dissection wound there must be an infection atrium, for the unbroken skin acts as a barrier against the introduction of the poison. This may be a cut or puncture inflicted while at work, or it may be an abrasion, received previously, of which the individual is unconscious. If is for this reason that rubber gloves are advocated when operating in the presence of pus, or when doing an autopsy on a subject who died of infectious disease.

Symptoms. These vary greatly—from slight local inflammation and suppuration to that of rapidly progressive gangrene. The wound generally becomes red, inflamed and swollen. There is a chill, followed by high fever, a rapid pulse and marked prostration. In bad cases lymphangitis develops and red lines lead from the seat of infection to adjacent lymph nodes, which become enlarged and tender, suppurate and break down. The prognosis will depend on the virulence of the poison and the resistance of the patient. If death ensues, it is the result of septicemia or pyemia.

Treatment. The prophylactic treatment consists in maintaining good general health, in disinfecting the hands carefully after doing an operation or performing a post-mortem, and, if the hands are abraded, protecting them by wearing rubber gloves. If an accidental wound is inflicted while handling septic material the hands should be immediately washed and the poison withdrawn as far as possible, by mouth suction. The puncture should then be enlarged and cauterized with pure carbolic acid and dressed with a hot antiseptic fomentation. It is also advisable to produce passive congestion of the part according to Bier's method, at stated intervals for the next one or two days. If, despite or owing to the neglect of these measures, the symptoms of local and constitutional infection make their appearance, the surgeon in charge of the case should not wait for suppuration to develop, but should make early and free incisions to open up the infected region and permit the free escape of poisonous fluid. This practice will relieve pain, save destruction of tissue, cut short the course of the disease, and, in many instances, will save life. The incision should be kept open by lightly packing with iodoform gauze, and the whole limb should be kept enveloped in a wet antiseptic dressing.

The constitutional treatment consists in the administration of anodynes to relieve pain, stimulants in the form of whiskey, strychnine and digitalis to overcome depression, and later, tonics, such as iron, quinine and arsenic to hasten convalescence.

STINGS OF INSECTS.

These are punctured wounds inflicted by the bite of various small animals. Although usually they are trivial, as is the case of a bite by a flea, bedbug or louse, they may be extremely painful when inflicted by a yellow jacket, wasp or hornet, and again, they may be actually dangerous when due to the bite of a spider, centipede, scorpion or tarantula. These wounds are punctured wounds, and, therefore, infected with ordinary pyogenic organisms. They are also inoculated with the poison of the insect inflicting the bite, and further, and most important of all, they are sometimes the infection atria through which the essential cause of constitutional disease, such as malaria, yellow fever and bubonic plague are transmitted. It is an unquestioned fact that malaria and yellow fever are conveyed from one individual to another by the mosquito, and that bubonic plague has its most frequent origin in the bite of infected fleas.

Symptoms. Individuals vary greatly in their susceptibility to bites of certain animals. For example, some people scarcely show the bite of a mosquito, while others suffer greatly. The symptoms also depend upon the nature of the animal inflicting the wound, the result on the same person being different from the bite of a flea, a hornet, or a scorpion. In general, the local symptoms are irritation, pain, heat, swelling and redness. If the locality be carefully examined, often the sting of the insect may be seen protruding. If the poison inoculated is virulent there may be vertigo, vomiting, delirium and prostration. Persons have been stung to death by bees, and in the tropics death is not at all uncommon from the bite of large spiders, scorpions and tarantulæ.

Treatment. Examine the wound, remove the sting and disinfect. As the poison of all insects is strongly acid, pain may be relieved by the application of some alkali, such as ammonia or bicarbonate of soda. Cold or heat is usually grateful. In case of virulent poison a constrictor should be applied above the bitten part, crucial incisions made to favor bleeding, and the wound finally cauterized and dressed antiseptically.

The constitutional treatment consists in combating the symptoms as they develop—morphine for pain, ammonia, strychnine and whiskey for cardiac depression, and later, tonics for general debility.

BITES OF SERPENTS.

These are wounds inflicted by the fangs of poisonous snakes. In America are found the rattlesnake, the ground rattlesnake, the moccasin, the harlequin snake, and a poisonous lizzard known as the Gila monster. In India there is the cobra, for whose bite there is no remedy, and the ophiophagus, a hooded snake, which grows from twelve to fourteen feet in length. In Virginia and North Carolina death from snake bites is comparatively rare, but in India, the mortality is frightful, it being estimated that 20,000 people die annually from this cause, due partly to the enormous number of serpents and also to the scanty clothing of the natives. A poisonous snake, unlike the constrictor, is short and thick, with blunt tail and a coffin-shaped head. Its upper jaw is movable and its ligaments so arranged that a snake can swallow an object larger than its own head. On the under surface of the upper jaw, at what would normally be the site of the canine teeth, are two fangs, which, in the rattlesnake, are about three-fourths of an inch in length. They are conical, curved and have a sharp point. On their posterior surface are deep grooves which give them the appearance of being hollow. The fangs communicate by a duct with the poison glands which are situat d back of the eye, beneath the temporal muscle. It is the presence of these glands which gives the sinister, angular outline to the snake's head. When the mouth is closed the fangs lie against the roof and are covered by a fold of mucous membrane, but when the snake opens its mouth to strike they fly forward in a position for action. The poison sac contains from ten to fifteen drops of venom. Its color varies from straw color to pale green. It exerts a more powerful local effect on living tissue and induces more rapid changes than any known organic substance. It causes blood to lose its power of coagulation, and acts upon the capillary vessels so that their walls are unable to resist the blood pressure and they rupture. Death from snake venom results from paralysis of the respiratory center. The mechanism of the act of striking is thus described by Yarrow:

"The snake prepares for action by throwing itself into a number of superimposed coils, upon the mass of which the neck and a few inches more lie loosely curved, the head elevated and the tail projecting and rapidly vibrating. At the approach of the intended victim the serpent, by a sudden contraction of the muscles upon the convexity of the curves, straightens out the anterior portion of the body and then darts forward the head. At this instant the jaws are widely separated and the back of the head fixed firmly upon the neck. With the opening of the mouth the spheno-palatines contract and the fangs spring into position, throwing off the sheath as they leap forward. With the delivery of the blow the penetration of the fangs, the lower jaw closes forcibly, the muscles that execute this movement causing simultaneously a gush of venom through the tubular tooth into the wound."

Symptoms. The symptoms of a snake bite depend upon the variety of serpent inflicting the injury and the amount of virus inoculated. The location of the bite is usually upon the hand or foot. Two parallel punctures will be found on examination, indicating the point of entrance of the fangs. Pain is variable, sometimes hardly noticed, and again severe. Swelling rapidly takes place, not due to inflammation, but to the effusion of blood. The tissue breaks down and will become gangrenous if the patient lives a sufficient time. The constitutional symptoms appear from a few moments to an hour after the bite. The patient feels faint, his knees give way beneath him and he may stagger and fall; the skin is cold and clammy, pulse rapid and weak, breathing irregular. There may be a sense of suffocation. In fatal cases these symptoms deepen and death takes place gradually from failure of respiration. In favorable cases the symptoms continue for some time and very slowly improve.

Diagnosis. The diagnosis is based on the history of the patient having been bitten, on the existence of a double punctured wound, and on the local and constitutional symptoms above described. The statement of the victim, however, cannot always be believed. A case is known where a small, barelegged boy going to the hen house for eggs, came flying back home, claiming to have been bitten by a snake and exhibiting two parallel punctured wounds on the calf of his leg, which afterwards were proven to have been inflicted by the beak of a setting hen, the location of whose nest was unknown to him.

Again, a person may be inoculated with snake venom without having been bitten. A young naturalist at one of the Virginia springs bought a dead rattlesnake and made a careful dissection of its head. The scalpel used was not disinfected and was left on his desk. Several days later he picked it up and, in a fit of abstraction, traced with its point the name of his sweetheart upon his arm. Shortly there was pain and swelling and he became nauseated and weak. A doctor hastily summoned applied a strong solution of nitrate of silver, when at once the letters became legible. The diagnosis was plain, and under proper treatment recovery ensued.

Prognosis. This depends upon the variety of snake and the amount of venom injected. The bite of a cobra is invariably fatal, whereas that of a rattlesnake need not be so if prompt treatment is employed. A snake has but a limited amount of venom in its glands. If it bites a dog and afterwards bites the hunter, the dog receives the greater portion of the poison and the man but a small quantity. Again, a bite inflicted through the clothing is less likely to prove fatal than one upon the bare skin.

Treatment. Treatment, to be efficient, must be prompt. A tourniquet should be applied above the wound to prevent the entrance of the poison to the general circulation. Every second counts, and the first thing that comes to hand must be used as the constrictor. A cravat, handkerchief, suspender, or pieces of grape vine should be thrown around the limb, knotted and twisted tight with a stick. As soon as this has been done the punctured wound should be enlarged with a knife and the poison removed as far as possible by sucking or by cupping. Next, the open surface should be cauterized. Fuming nitric acid may be used if available, but usually a thermo-cautery, in the shape of a piece of iron heated in a fire, must be employed. It is stated that frontiersmen in the West fill the wound with powder and then ignite it.

The constitutional treatment consists in combating prostration by the use of stimulants. Alcohol is a favorite remedy. It should be given in moderate quantities; in too large doses it causes depression. Its injudicious use is responsible for perhaps one-half the deaths which occur after snake bite in this country. Other remedies employed are morphine, strychnine and digitalis. The patient should be kept in a recumbent position, wrapped in blankets and his excitement and fears combated by a composed manner and reassuring words. After the constitutional symptoms improve the tourniquet is loosened for a moment and then again tightened. The additional poison admitted to the system causes renewed symptoms, which are treated as in the original instance. Thus by repeated loosening and tightening of the tourniquet the poison is given the patient in broken doses. Good judgment is necessary in the management of the tourniquet, for, if left on too long, gangrene of the extremity will take place, while if taken off too soon, an overwhelming amount of poison may be admitted to the general system. In India much work has been done by the Government in an effort to secure a serum for a bite of the cobra. It has been found possible to render an animal immune, but up to this time little success has been attained in curing animals after they are bitten.

LECTURE XLV.

WOUNDS (CONTINUED)—CONTUSIONS AND BRUISES, BURNS AND SCALDS—CAUSES, PATHOLOGY, SYMPTOMS, DIAGNOSIS, PROGNOSIS AND TREATMENT.

CONTUSIONS AND BRUISES.

A contusion or bruise is an injury produced by the impact of a blunt body by which there is laceration of the subcutaneous tissues, without breach of the continuity of the skin. They vary in degree from a pinch on a girl's arm to the pulpification of a man's limb in a railroad accident.

Pathology. A contusion or bruise is a subcutaneous injury, the overlying skin or mucous membrane not being manifestly broken. Blood vessels may be torn, nerve fibrils injured, muscles ruptured, fat and fascia pulpified, but the wound is protected from external influences by an intact epithelial covering. When large vessels are ruptured, hemorrhage is considerable and the blood which coagulates in the tissue spaces is called a hematoma. When small vessels are ruptured, hemorrhage is moderate, and the discoloration which results is called an ecchymosis. Subcutaneous bleeding, the result of a contusion, usually ceases spontaneously, due to the reactive pressure of the surrounding tissue. Blood which escapes is usually absorbed, the fluid elements being taken up by the lymphatics, and the corpuscular elements either returning to the circulation or being broken up and removed. The destruction of the red cells sets free pigment which stains the tissue.

Symptoms. Shock is always more or less obvious. It may be trivial as in a bruise inflicted by a playful pinch on a pretty girl's arm, or profound and fatal, as is sometimes seen in a contusion of the head or abdomen. *Pain* is not usually great at first, as the impact of the blunt body obtunds the nerves and destroys their conductivity. It usually comes on later and may be agonizing. *Swelling* is always seen to a greater or less degree, due to the transudation of serum or the escape of blood into the tissues. It varies with the looseness or compactness of the part injured. The swelling attending a "black eye" is much greater than that resulting from a mashed finger. *Discoloration* of the skin quickly appears in contusions of superficial tissue, but is often delayed several days when injury to deep tissue occurs. A bruise inflicted by pinching the skin becomes blue within a few minutes, whereas a contusion produced to a woman's breast by a fall will not be attended by discoloration for several days, and when it appears, will be in the shape of a crescent below or a ring around the mammary gland.

The discoloration of a bruise is first purple or black, and, as it fades, becomes green, and finally yellow. This is due to a chemical change in the hematoidin, which is not well understood. After a contusion there is local soreness and pain upon movement, which, under rest and proper treatment, slowly subsides. In some cases there is atrophy, due to injury to trophic nerves, or contraction and permanent loss of power. Occasionally infection may take place, and acute or chronic inflammatory conditions follow.

Diagnosis. The part is tender, becomes swollen, and sometimes shows a local elevation of temperature. Discoloration is always present, occurring immediately when there is subcutaneous hemorrhage, and after a few days when deeper structures are lacerated.

Prognosis. The prognosis depends on the nature and location of the injury. Some bruises are so trivial as to pass unnoticed, while others are so severe that death soon follows.

Treatment. The general treatment consists in measures to combat shock and remedies to relieve pain. The local treatments consists in, first, giving the injured part rest, which may be effected by the use of apparatus such as splints or slings or confining the patient to bed. If there is much hemorrhage or serous effusion, *elevation* and *compression* should both be used.

Compression may be effected by strapping with adhesive plaster, applying a rubber bandage, or by placing a voluminous dressing of cotton over the injured part and confining it so as to make it exert, through its resiliency, a uniform, equable pressure. The use of *cold* and *heat* are time-honored remedies and do much good if properly employed. Cold is indicated when the injury is hot and painful and when there is no danger of gangrene from impaired nutrition. It may be employed in the form of ice-bags, cloths wrung out of cold water, or by the use of evaporating lotions containing camphor, witchhazel or arnica. Heat is useful when the injury is severe, and, owing, to the disorganization of tissue, there is danger of necrosis. It may be employed in the form of hot water bags or warm fomentations. After the acuteness of the injury subsides, *massage* and *stimulating liniments* are of value. They aid the circulation, break up coagulated lymph and improve the nutrition of the tissue. While an incision into a contused area is always to be deprecated, as it opens up devitalized tissue and endangers infection, still, in rare instances, it has to be done. It is sometimes indicated shortly after an accident, in order to ligate a vessel which continues to bleed, and again, several weeks after the injury, to remove a hematoma which refuses to be absorbed.

BURNS AND SCALDS.

A burn is an injury inflicted by dry heat; a scald is an injury inflicted by moist heat. A burn is usually localized, while scalds are often more extensive, because the clothing diffuses the fluid over a greater area. They are identical in their pathology and treatment, and will, therefore, be considered together. They vary in severity, depending on the degree of heat applied and the length of time the tissues are subjected to it. The classification of burns, as given by some authors, is extremely complicated. For practical purposes, only three classes need be made, viz: those of the *first degree*, which involve the superficial layers of the skin and are characterized by redness, without vesication; those of the *second degree*, which involve the corium and are characterized by the formation of vesicles and bullæ, and those of the *third degree*, which destroy the entire skin and partially or completely carbonize fat, fascia, muscles and underlying structures.

Pathology. There is destruction of tissue by the coagulation of the albumen of the cells, resulting in necrosis or gangrene. Blood may be coagulated in the vessels or may be so changed as to cause increased adhesiveness of the corpuscles, resulting in thrombosis and embolism. Burns of the first degree are characterized by erythema or redness, attended by engorgement of the blood vessels of the superficial layers of the skin. Burns of the second degree are characterized by the formation of vesicles filled with serum, due to the involvement of the rete mucosum and the corium. Burns of the third degree are characterized by destruction of the skin and subcutaneous tissue, with carbonization and the formation of an eschar.

Symptoms. *Pain* is sharp and excruciating, the character and degree depending on the depth and extent of the burn. Burns of the first degree are more painful than those of the third, on account of the fact that in the former the nerves are exposed, while in the latter the nerves are destroyed. *Redness* quickly appears after a burn and is most prominent at the margins. This is due to inhibition of the vaso-constrictor nerves and consequent engorgement of the blood vessels. *Swelling* of the injured part occurs, and is due to the escape of serum into the tissue, from increased porosity of the capillary walls. The amount of swelling depends upon whether the tissue injured is loose or compact. *Vesication* or bleb formation is due to separation of the layers of the skin and the accumulation of serum between them. *Carbonization* or eschar formation consists in the destruction of a large mass of cells, which die and are separated from the adjacent tissue. The eschar is sometimes black, although it may be yellow or white. It may remain dry and slowly separate, or it may become infected, liquefy and disintegrate.

The constitutional symptoms of a burn consist in a rapid, weak pulse, shallow respiration and subnormal temperature—in other words, shock. In severe cases, this prostration is succeeded by delirium and death; in most cases, however, there is reaction, followed by fever. There may be vomiting, diarrhea and congestion of the internal organs. The blood changes are peculiar and interesting. There is increase in the number of red blood cells, caused by venous stasis and by loss of blood serum. There is also increase in number of the white blood cells and of the third blood cells. The blood, as a whole, shows a marked tendency to coagulate, and small intervascular clots may be thrown into the circulation and cause damage to distant structures or organs. The liver and the kidneys are the frequent seat of infarcts from thrombosis and embolism. Often there is inflammation of the duodenum, followed by ulceration, which sometimes results in perforation. For a time it was supposed that this was due to emboli, but more recently the theory of William Hunter has been adopted, who explains the condition as the result of the irritation of bile, which has been altered by the elimination of toxic materials through the liver. In bad burns, there is usually albuminuria, and sometimes hemoglobinuria. Often the kidneys cease functionating and death results from uremia. Pneumonia and meningitis are also occasionally fatal complications. Owing to the presence of an open wound, infection commonly occurs, with local suppuration and general septicemia. As a result, there may follow ulceration, cellulitis, gangrene, erysipelas or tetanus.

Prognosis. The prognosis of a burn depends upon the age and general condition of the patient. The very old, the very young, and the feeble and debilitated, giving high mortality. It also depends on the depth and extent of the burn. The depth of the injury does not make as much difference as its extent, for the same person may recover from the effect of having an extremity carbonized, while he would surely die if two-thirds of his cutaneous surface was merely reddened by a burn of the first degree. This is perhaps due to the sudden arrest of the elimination of effete products through the sweat and other cutaneous glands, and the overwhelming amount of work thrown upon the kidneys which, already engorged, are unable to meet the demands made upon them.

Treatment. The immediate treatment of burns consists in remedies to relieve pain and to combat shock. The patient should be placed in a warm, quiet room, external heat applied and stimulants and morphine administered hypodermically.

The Local Treatment. The clothing should be removed and chilling prevented by keeping the unburned parts of the body carefully covered with a blanket. In severe burns it is usually necessary to administer an anesthetic in order to disinfect the part and apply an appropriate dressing. Fragments of skin, particles of dirt and clothing should be carefully cut away. Blebs or blisters should be opened and the entire area should be washed with green soap and warm water, irrigated with a carbolic acid solution and afterwards with alcohol. This being accomplished, one of the following four methods may be adopted: First, the application of a moist dressing; second, the application of dusting powder with dry dressing; third, the application of oils or ointments, and fourth, the open air method of treatment.

1st. The moist dressing consists in saturating a pad of cotton or gauze with normal salt solution, bicarbonate of soda, hydrate of chloral or acetate of aluminum solutions, placing it over the burned surface, covering it with oiled silk to prevent the escape of heat and moisture, and retaining it in position by suitable bandages. The pad should be removed and replaced once or twice in twenty-four hours. A moist dressing which has given unusually good results is a solution of picric acid. It must be used with caution, however, if the burn is large or the patient is small, for fear of systemic poisoning. Gauze saturated with a one per cent watery solution of picric acid is laid upon the burned area. This is covered with dry absorbent cotton and securely fastened in place. The first dressing is not changed for from three to five days, and the next dressing should be left on until the wound has healed.

2d. *The Use of Dusting Powders* has many advocates. After the burned area is disinfected, it is thickly powdered with iodoform or with a mixture of three parts boracic acid and one part salicylic acid, or with one of the numerous proprietary antiseptic powders on the market. The surface is then covered with gauze, a pad of cotton, a layer of oiled silk, and the whole confined by a bandage. In favorable cases this may remain without change until epidermization is complete, healing taking place under it as it would under a large aseptic scab.

3d. *The Use of Oils and Ointments* has been largely employed in the past, but is generally discouraged by modern teachers. The advantages are the ease of application and the almost instant relief they afford by excluding air. The objection is the almost certainty of infection, with prolonged suppuration and tedious convalescence. The oleaginous dressing with greatest reputation is called carron oil, named after an iron foundry in England where it was first used for accidental burns on laborers. It consists of a mixture of equal parts of linseed oil and lime water. It readily undergoes putrefaction and has no place in modern practice. There is a substitute known locally as Peple's Antiseptic Grease, which acts as efficiently and is freer from objections. Its formula is castor oil, 94 parts; balsam Peru, 5 parts; carbolic acid, 1 part.

4th. *The Open Air Treatment* for burns is the newest and latest method, and has many ardent advocates. It consists in the disinfection of the burned surface and then its exposure to air, without protection by any overlying dressing. If the burn be extensive, the patient is kept nude in a room, the temperature of which is maintained at about 110° F. The serum which escapes from the burnt surface soon dries and forms a scab and healing occurs rapidly under this aseptic shield.

General Treatment. Patients, the victims of burns, should be well nourished, their bowels carefully regulated, the function of the kidneys watched, and, if necessary stimulated. Iron, quinine and alcohol should be prescribed to support the system under the drain of prolonged suppuration, and complications, such as penumonia, pleurisy, peritonitis or sepsis, combated with the usual remedies. The scars which result from burns and scalds are almost certain to contract, and sometimes result in serious deformity. This should be prevented as far as possible by position, splints, active and passive motion, and later, if necessary, by operative measures. When large areas are burned, healing may be so slow that it may be necessary to hasten epidermization by skin grafting.

X-Ray and Radium Burns. After exposure of the skin to the X-ray or powerful radium salts, there is sometimes noticed, a few days later, a reddening or pigmentation of the surface. In some cases the result is simply an erythema, attended by loss of hair; in other cases blisters form filled with blood, which break down and develop into an ulcer. In severe cases there is necrosis not only of the surface epithelium, but of the underlying connective tissue. An ulcer due to the action of X-ray or radium frequently causes excruciating pain and refuses to heal under all local treatment. When this condition is met with, the only way to correct it is by extirpation of the diseased area, and covering it with skin, either by grafting or plastic work.

Burns and Scalds of the Tongue, Pharynx, Glottis and Epiglottis. A child or lunatic may drink boiling fluid or may inhale steam from a tea kettle. Firemen occasionally suffer from being suddenly enveloped in a cloud of hot steam or from inhaling hot vapor or flame. The symptoms which follow are great swelling, severe pain, large vesicles, accompanied by difficulty in speaking or swallowing. The treatment consists, in combating shock, relieving pain and constantly giving the patient bits of ice to suck. If swelling of the tongue is great, multiple longitudinal incisions should be made on its dorsum. In cases of edema of the glottis, intubation or tracheotomy may be necessary.

Burns of the Esophagus. The esophagus is rarely scalded, since a boiling fluid seldom goes below the pharynx. A strong acid or alkali, however, may be swallowed, producing, to all practical purposes a burn. Such accidents cause shock, difficulty of breathing, violent pain and bloody vomiting. Perforation may occur, and in many cases severe gastritis results as a complication. These wounds are extremely liable to be followed by stricture of the esophagus.

Treatment. Some remedy should be immediately administered to neutralize the caustic. If, as is usually the case, it is concentrated lye, then an acid, such as vinegar, should be employed. Large draughts of water should also be given. Feeding by the mouth should be avoided for some days. Rectal alimentation may be practiced, but many surgeons claim that a patient cannot be sustained a sufficient length of time by this method, and advise the operation of gastrostomy immediately after the accident, in order that food may be directly introduced into the stomach, without irritation to the inflamed esophagus. When mouth-feeding is begun, the food should, for some time, consist of liquids. After two or four weeks, the use of esophageal bougies should be resorted to, in order to prevent stricture.

LECTURE XLVI.

ASEPTIC SURGICAL TECHNIQUE—PREPARATION OF PATIENT FOR OPERATION—PREPARATION OF OPERATING ROOM AND ACCESSORIES—AFTER CARE OF PATIENT—TECHNIQUE IN COUNTRY PRACTICE.

The principles of aseptic and antiseptic surgery are fixed. The methods adopted for the application of these principles to practice, vary with the environments of the surgeon, the character of his work, and his conception of what is essential and what is not essential to success. Lack of space prohibits a description of the various ways by which different men endeavor to accomplish the same object; hence the following is simply an outline of the methods followed in St. Luke's Hospital, of Richmond, Va. No claim is made for originality, as almost every detail has been derived from outside sources, nor is it believed that perfection has yet been reached, as changes from time to time are still found advisable. All that can be said is that results are very satisfactory.

An earnest effort has been made to fulfill the requirements of Ochsner who states that to attain the best results a technique must be (1) *simple* so that defects may be readily detected, (2) *uniform*, so that assistants may be drilled to do the same thing in the same way, and (3) *reasonable*, so that the end desired is always understood and nothing is done without a purpose. What Price calls "fuss, feathers and foolishness" has been discarded.

The subject will be divided for discussion into the preparation of the patient, the preparation of the operating room with its accessories, and the after care of the patient and the wound.

I. PREPARATION OF THE PATIENT.

If practicable the patient is admitted to the hospital several days before the operation, and for the last forty-eight hours is confined to bed. This gives the surgeon an opportunity to study the case and allows the patient to become accustomed to the new surroundings. The heart and lungs are carefully examined to determine the safety of the anesthetic, and the urine analyzed to ascertain the condition of the kidneys, and the patient is studied carefully and repeatedly with reference to details of structure and function for we are dealing with individuals as a whole as well as with their diseases. Complete histories and physical examinations of each case are made and recorded. The bowels are carefully regulated, and the patient is urged to drink abundantly of water. A daily tub bath is ordered, also an antiseptic douche, if the case be a gynecological one. The regular use of the tooth-brush and of antiseptic mouth wash is directed. The diet is simple and nutritious and of a character to leave little residual matter in the intestines. If the bowels contain an excess of gas a tablet is prescribed composed of resorcin, rhubarb, bismuth and sodium sulphate, known locally by the druggists as C. R. Tablets. The night before the operation the field of operation is cleanly shaved and the patient given a warm tub bath. The site is then disinfected by thoroughly scrubbing with hot water and green soap, bathing with a 70 per cent solution of alcohol, then with a 1-1000 solution of bichloride of mercury, and finally a moist bichloride compress is applied which is retained in place by a bandage or binder. For shaving a sharp clean razor is used, and in scrubbing a mop of soft gauze employed. It has been found that a dull razor and a stiff brush cause pain and roughen or excoriate the skin so as to make it readily susceptible to infection.

After the foregoing is completed the patient is put in a clean gown and made comfortable in bed. If there is any evidence of exhaustion a cup of beef tea is given. Before going to sleep a purgative is administered. Castor oil is the one preferred, but if the patient objects to it two compound blue pills are substituted. They are known locally as C. B. Pills and consist of aloes, rhubarb, blue mass and colocynth.

If the patient is restless or nervous fifteen grains of chloretone are given. This not only induces sleep but seems to have some effect in lessening or preventing nausea after the anesthetic. Next morning as soon as the patient awakes, a saline aperient is given, and this is shortly followed by a soap suds enema. No food is given by mouth for four hours before the operation, and the bladder is emptied immediately before the administration of the anesthetic. When the hour for the operation arrives the nurse pins a blanket tightly around the patient's limbs from pubes to heels, securely fastening it so as to make a neat, compact roll. The gown is then pulled down over it. A wheel stretcher is brought to the bedside, a second blanket thrown over it and the patient placed on it and transported to the anesthetizing room. It is bad practice to begin the anesthetic in the patient's bed room, for while it removes one of the disagreeable features of an operation, it is attended by a prolongation of anesthesia and consequent increased liability to shock and nausea. The anesthetizing room adjoins the operating room and is furnished with two small tables. One table is for the anesthetist and contains chloroform, ether, masks, towels, vaseline, gag, tongue forceps, pearly of amyl nitrite and two hypodermic syringes, one loaded with ¼ gr. of morphine the other with 1-20 gr. of strychnine. The other table is for the materials to be used in the second sterilization of the site of the inc.sion. Upon it are sterile mops for scrubbing, a fenestrated sheet, five sterile towels and four glass flasks, containing respectively tincture of green soap, 70 per cent solution of alcohol, sterile water, and 1-1000 bichloride solution (the last two warm). As soon as the patient reaches the anesthetizing room the anesthetic is commenced. After unconsciousness has ensued the operating table is brought in, placed alongside of the wheel stretcher and the transfer of the patient from the one to the other effected. Now all should move quickly and smoothly, for rapid, systematic work will reduce the time of anesthesia by many minutes, a matter of importance in most cases. The patient is fastened to the table by two cotton bandages, one just above the knees and the other just above the ankles. The arms are extended by the sides and fastened by broad bandages about the wrists, care being taken not to constrict them. Thin rubber pads are pushed under the elbows to prevent them chafing against the table. All knots used in fastening the patient are half bows which can be readily loosened. The protective dressings are removed from the site of operation. Light oil cloths are placed so as to protect the gown and blankets and the field is again prepared as on the night before. A clean assistant scrubs it with green soap and sterile water, going wide and including all land marks which the surgeon may desire to locate. Undue wetting and chilling of the patient are carefully avoided. The soap is rinsed off, then completely removed by free use of 70 per cent alcohol, after which it is washed with a 1-1000 bichloride and covered with a towel soaked in the same solution. Sterile towels are placed over the rubbers and a sterile fenestrated sheet over the whole. The patient is now rolled into the operating room. This second sterilization of the site is a step of extreme importance, for the itching induced by the early preparation often impels the patient even though asleep, to seek relief by thrusting a hand beneath the bandages and thus contaminating the skin.

II. PREPARATION OF THE OPERATING ROOM AND ITS ACCESSORIES.

The operating room is the heart of every surgical hospital. On it are lavished more time and money, and to it are given more care and thought than to any other part of the institution. And rightly so, because on it and its proper management depend in no small degree the life of the patient and the reputation of the surgeon. A graduate nurse is in control of the operating room and she is responsible for its management. There is no division of authority, for here as elsewhere success can be achieved in its highest degree only when there is one head. Assistants loyally, faithfully and conscientiously do their part but they are subordinates. They are not changed too freqeuntly as good work is essential and efficiency comes only with experience. The members of the operating staff are drilled until they know how to get clean and stay clean. They are made to feel the great responsibility entrusted to them. In them is inculcated the "Belief in the Aseptic Idea," which leads to the development of the "Surgical Conscience." A well trained assistant should feel instinctively a contaminating touch, or a break in technique, as the musician feels the rasp of a false note, or the teacher the jar of a double negative.

DESCRIPTION OF THE OPERATING ROOM.

The operating room has a tiled floor, tiled wainscoting and waterproof walls, which can be washed or wiped down. In addition to a bountiful supply of daylight coming from a skylight above and large windows on the sides, it has electric lights and is so heated that its temperature can be easily maintained at 80° F. It is also provided with large porcelain washstands, with hot and cold water, the flow controlled by foot pedals. These basins are used exclusively for washing the hands. There is a porcelain sink in one corner for emptying waste water, etc.

The furnishings of the operating room are rigidly simple. There are no shelves with bottles for solutions or jars for materials to catch dust. There are no cases for instruments as they occupy space and their contents rust in the steam-charged atmosphere. In short, there is nothing in the room that is not to be actually used during the operation, and nothing that would prevent the room from being quickly and thoroughly cleaned and disinfected.

The necessary equipment consists of: (1) an operating table, (2) a glass or metal topped instrument table, (3) a sponge table, (4) a stand for solution basins, (5) two light stands for hand basins, (6) water sterilizers for hot and cold water, (7) a glass irrigator with rubber tube and hard rubber or glass nozzle, (8) a small metal stool. In an adjoining room easy of access there are (9) an autoclave sterilizer, (10) an instrument boiler, and (11) a utensil sterilizer for boiling basins, trays, etc. The last three are purposely located in a separate sterilizing room, because an open flame cannot be used in the operating room during the administration of an anesthetic, owing to the fact that the vapor of ether is inflammable, and that of chloroform is decomposed, liberating chlorine, which is extremely irritating to the lungs of both operator and patient. The various tables and stands enumerated are covered with white enamel paint, which protects the metal and can be re-applied whenever needed.

PREPARATION OF THE OPERATING ROOM FOR AN OPERATION.

Sterilization of Linen. On the morning of the operation the sterilizer is packed with all gowns, caps, sheets, table covers, towels, dressings and sponges that are to be used. These are placed so loosely that the steam can readily gain access to all parts of every article. In an autoclave thus packed thirty minutes of steam at fifteen pounds pressure has been found by actual test to be sufficient to completely exterminate all organisms and their spores.

Sterilization of Basins, Pitchers, etc. The agate and porcelain basins, instrument trays and pitchers are boiled in the utensil sterilizer for ten minutes before each operation. As disinfection by hot water is much the simplest method, in the absence of a regular utensil sterilizer, one should be improvised by putting an ordinary tin wash boiler on a gas stove.

Cleaning and Arrangement of the Room. Every one or two weeks, the time depending on the character of the work done, the operating room is filled over night with formaldehyde gas. This is done to exterminate germs that may have collected in inaccessible places. The morning of the operation, the walls and floor of the room are washed, and the tables and other furniture are wiped with a 1-1000 bichloride solution. Any dust in the air is precipitated by allowing an escape of steam from the water sterilizers. The nurse in charge arranges all furniture and sees that everything is in proper place. She puts the basins and trays in the utensil sterilizer, the instruments in the instrument boiler, and opens the door of the autoclave. Having, as far as possible, done everything that could be done before sterilizing her hands, she next proceeds to disinfect them and put on her sterile gown and rubber gloves. She now unpacks the autoclave, covers the instrument and sponge tables with sterile sheets, places the instrument trays, solution and hand basins and sets out every article to be used in its assigned position. She is aided in this work by an assistant who fills the solution and hand basins, makes up the salt solution and performs every duty that would entail soiling of the other's hands. The clean nurse quickly performs her task without once contaminating her hands. A technique, broken by frequent rushes to the solution basin to resterilize hands, is faulty and dangerous. The instruments, sutures and ligatures are now brought in and arranged ready for use, with as little handling as possible. Finally, the patient is rolled in from the anesthetizing room and the operation begun.

DUTIES OF ASSISTANTS.

The number of assistants varies with different operators, and with the same operator under different circumstances. The following is a convenient division of the work.

The Anesthetizer stands at the head of the table. A tank of oxygen fixed for use should be within easy reach. His duty consists solely in administering the anesthetic, which requires his undivided attention.

The First Assistant stands to the left of the table opposite the surgeon. He sponges the wound, catches bleeding vessels, and assists the operator in any way possible. He should anticipate the needs of the surgeon and direct the work of the other assistants.

The Instrument Assistant stands behind and to the right of the surgeon, at the instrument table. He passes instruments, ligatures and sutures to the surgeon as needed, keeping instruments in place, and assisting otherwise when requested.

The Sponge Nurse stands behind and to the left of the first assistant. She has charge of the sponges, diaphragms, dressings, drainage strips and sterile towels. She passes sponges to the first assistant and supplies diaphragms wrung out of hot salt solution. Of these she keeps accurate account so that none may be accidentally left in the abdomen or wound. At the completion of the operation she recounts them to see that all are in hand.

Extra Assistant, or "Dirty Nurse." The assistants who have been designated have all to work with sterile hands, and should they in any way accidentally contaminate them they must immediately clean them again. The extra assistant performs all such duties as would necessitate soiling the hands of the others, such as readjusting the patient on the table, emptying and refilling solution basins, opening or closing doors, attending to wants of the anesthetizer, and the innumerable little duties that promote harmonious working of the entire staff.

Preparation of Water. An abundance of water is needed for preparing the site of the operation, making and replenishing solutions, and supplying fresh water for the hands of the operators. Water should first pass through a close filter to remove any organic or inorganic matter suspended in it Boiling for ten minutes renders it sterile. Two tanks are kept in the operating room, one of cold and one of hot sterile water, so the extra nurse can make a solution of any desired temperature by mixing them at a moment's notice.

Preparation of Solutions. Many solutions are used, to disinfect the hands of the surgeon and the skin of the patient, to irrigate infected wounds and cavities, and to warm and moisten gauze diaphragms that are to protect exposed viscera.

Normal Saline Solution is prepared by dissolving three drachms of sodium chloride in one half gallon of water. As this often has to be quickly done during the process of an operation, it is necessary to have sterile salt in readiness. This can be done by sterilizing the salt in an open mouth bottle in the autoclave, or by having a concentrated solution (three drachms to the ounce), that has been boiled for ten minutes.

Bichloride Solution. This is used in strengths varying from 1-1000, employed in sterilizing the hands and skin of the patient, all the way down to 1-10,000, used for irrigation of wounds and cavities. It can be quickly prepared by dissolving in a given quantity of sterile water the number of tablets of bichloride of mercury specified on the bottle by the manufacturer to make the desired strength. When used in large quantities, it is cheaper to keep a concentrated solution; say thirty grains of bichloride of mercury, two and one-half minims of hydrochloric acid, and a small quantity of methylene blue, to the ounce of water. One ounce of this solution to one-half gallon of water makes a 1-1000 solution.

Thiersch's Solution is used especially for irrigating the bladder. It is prepared by dissolving one drachm of salicylic acid and six drachms of boracic acid in one-half gallon of water.

Carbolic Solution. Carbolic acid is a most effective germicide and at one time was much used. Numerous accidents, however, have occurred by mistaking it for alcohol or water, and these have lessened its popularity. For irrigating wounds, and douching the vagina, a solution is prepared by adding one ounce of carbolic acid to one-half gallon of water. It is well to remember that alcohol is an effectual agent to neutralize carbolic acid in case of accidental burns by this substance.

LECTURE XLVII.

ASEPTIC SURGICAL TECHNIQUE (CONTINUED)—PREPARATION OF PATIENT FOR OPERATION—PREPARATION OF OPERATING ROOM AND ACCESSORIES—AFTER CARE OF PATIENT—TECHNIQUE IN COUNTRY PRACTICE.

STERILIZATION OF THE HANDS.

The hands of the operator and his assistants are the more frequent sources of wound infection, hence their proper sterilization is the most important feature of the technique. The arms are bared above the elbows, the skin should be free from abrasions, the finger nails closely trimmed, and rings removed if worn. The practice of washing a little for minor operations and more for graver ones should not be tolerated, for such lowering of the standards of cleanliness is sure to lead to slurring of other details of technique, which some day will end in humiliating disaster. The operating room with the highest standard uniformly maintained will show in the long run the fewest number of infected wounds.

Hands that are cracked and fissured, with split and hang nails upon the fingers, are unsurgical, for they are too stiff for easy, dexterous movement and too rough to be readily cleaned. There are many methods of sterilizing the hands, some simple and some complicated. The following will be found an effectual process:

1. Wash the hands in warm water and green soap. When the nails are softened, pare and clean them with a sharp, clean knife. Scrub vigorously with a nail brush, taking them systematically, finger by finger, palm, sides and back, soaking them from time to time in warm suds. Rinse them in running water, and repeat the process until fifteen minutes are thus consumed.

2 Immerse in 70 per cent alcohol, rubbing the arms until all trace of the soap is removed. This should consume two minutes.

3. Soak them for two minutes in 1-1000 bichloride solution.
4. Wash them in warm sterile water to remove the bichloride.

Should a sterile hand at any time during an operation come in contact with any article that is not surgically clean, it should immediately be immersed in the bichloride solution.

Rubber Gloves. An effective method of securing sterile hands is to encase them in rubber gloves which have been disinfected by being boiled. The hands should be sterilized as described above before putting on the gloves, else an unseen hole or accidental tear may liberate infected sweat into the wound. The rubber glove has many advantages and but one disadvantage. With them we present hands as clean as though they had been boiled. Not only do they prevent infection of the wound, but they also prevent infection of the hands from dirty wounds, a matter of extreme importance when other cases are to follow. The one disadvantage is that it is difficult to do fine and delicate work with them, for they obtund the sense of touch and make difficult the handling of the slippery abdominal viscera. Practice will, however, overcome many of their objections. All assistants should wear them during an operation, and the surgeon should also wear them save in rare cases when they would materially interfere with the quality of the work or unduly prolong the operation.

As previously stated, rubber gloves should be boiled for ten minutes before each operation. When the day's work is over, they should be washed, dried and carefully inspected for defects. Needle pricks and other small holes can be repaired by patching them with a piece from an old glove and Goodrich's cement No. 4.

SOAP AND NAIL BRUSHES.

Green soap as purchased on the market is usually infected. Even if sterile it soon becomes contaminated if placed in an open bowl on the washstand where the surgeon and staff have access to it. Soap should therefore be sterilized by boiling and guarded against subsequent infection. There is a soap container for sale by Powers & Anderson, of Richmond, that fulfills all requirements. In its absence a number of mugs should be partly filled with soap, sterilized in the autoclave, and a fresh one used for each operation, the soap being removed with a spoon, by the different individuals requiring it. Nail brushes are essential for the proper mechanical cleaning of folds of the hands and the spaces around the nails. An inexpensive type should be bought, so that each member of the staff may have a separate one for each operation. Nail brushes should be sterilized in the autoclave before using. Immersion in a bichloride solution so softens them that they soon become worthless. They should be placed on a sterilized towel convenient to the wash basins and after being used should be thrown in a receptacle provided for them. After the day's work is over, they should be washed, boiled and dried.

INSTRUMENTS AND THEIR STERILIZATION.

Instruments should be simple in construction so that they can easily be taken apart and cleaned. They should be kept bright and free from rust. They should be washed, boiled and dried after each operation. Just such instruments as are necessary should be selected for any operation and no others. The table should not be crowded with instruments that will not be used, nor should the patient be subjected to delay while forgotten instruments are sterilized. All instruments including knives and needles should be sterilized by boiling for ten minutes. It is unnecessary to put bicarbonate of soda in the water, for if the water is boiled for five minutes before the instruments are put in the free oxygen of the water will be driven off and there will be no rusting.

Knives should be sharpened on a whetstone and leather strop before each operation, just as one sharpens a razor each day before shaving. The temper of the steel will not be materially affected by boiling, and this will be found far safer than the old method of immersing them in pure carbolic acid.

PREPARATION AND STERILIZATION OF LIGATURES AND SUTURES.

Ligatures and sutures naturally divide themselves into two classes: (1) absorbable, and (2) non-absorbable. The absorbable suture is the ideal suture, for it disappears when its mission is accomplished. It has, however, a great practical disadvantage. It is extremely difficult to sterilize, for it cannot be boiled in water. Non-absorbable sutures are readily sterilized by boiling in water, but do not disappear when the wound is healed. If upon the surface they must be removed, and when buried they remain as foreign bodies to be encapsulated by the tissues.

Absorbable Ligatures and Suture. By the term absorbable suture we mean catgut, for while kangaroo tendon belongs to the same class it has no special advantage over catgut.

Methods of Preparing Catgut. The problems to be met are three. (1) to render it absolutely sterile without injury to its tensile strength; (2) to preserve it in this state until it is needed; (3) to harden it so that it will resist absorption for a definite time. This latter step is only necessary for certain special operations, and, as chromic acid or some chromate is usually the hardening agent, such catgut is called chromicized catgut, while the other is termed plain catgut. Both plain and chromic catgut can be purchased in sealed glass tubes, numbered according to size, all ready for use, and unless it can be prepared under favorable surroundings by competent persons it is better to depend on some reliable manufacturer, who has a business reputation at stake, than to attempt its sterilization.

The following is the method employed at St. Luke's Hospital:

1. Take German catgut of any desired size, cut into convenient lengths—say thirty inches —and make into little coils about as large as a silver quarter. These coils are then strung like beads on a thread so that the whole quantity can be conveniently handled by simply grasping the thread.

2. The string of catgut coils is next baked in a hot air sterilizer to remove moisture and fatty matter. The shelf on which it rests should be covered with gauze or blotting paper. The temperature should be slowly and gradually raised to prevent char-

ring. Beginning at the temperature of the room the temperature is raised by regulating the burner to 140° F. at the end of the first hour, to 160° F. at the end of the second hour; to 180° F. at the end of the third hour; to 200° F. at the end of the fourth hour, and to 220° F. at the end of the fifth hour.

3. The catgut is next placed in liquid albolene, where it is allowed to remain until perfectly "clear," in the sense that the term is used in the preparation of histological specimens. This is accomplished in a few hours, though it is usual to allow the gut to remain in the oil overnight. The transfer of the catgut from the hot air sterilizer to the liquid albolene should be made as soon as the baking is completed in order to prevent reabsorption of moisture. The albolene should be warmed to temperature of 220° F. before the gut is put in it to prevent sudden cooling.

4. The vessel which contains the albolene is usually a glass specimen jar. It should have an inner cage made of wire gauze to prevent the catgut from coming in contact with the sides or bottom. After the gut has become clear, the vessel containing the oil is placed on a sand bath and the temperature rapidly raised so that at the end of an hour and a half the thermometer registers 317° F. The flame is then turned off and the jar left on the sand bath to cool to room temperature.

5. The thread is then seized with sterile forceps, the catgut is lifted out of the albolene and allowed to drip until the excess of moisture is removed. It is then put in a jar containing a solution of iodine crystals, one part, and Columbian spirits (deodorized methyl alcohol), one hundred parts. The thread is then cut and withdrawn, leaving the coils free. Care should be taken not to overcrowd the solution; else white spots will show in the gut where pressure prevented the iodine from reaching it. The catgut is permanently stored in this solution. It is ready for ure in twenty-four hours and will keep indefinitely.

The profession is indebted to Dr. Willard Bartlett of St. Louis for this method. The heat to which the gut is subjected makes the sterility absolutely certain; the oil with which it is saturated makes it soft and pliable; the iodine with which it is permeated makes it antiseptic, prevents its becoming infected, and acts like chromic acid to increase the time taken for its absorption. The advantage of the method over the iodine process introduced by M. Claudius is that no water is employed; hence the gut does not deteriorate and lose strength. The advantage over the cumol method is greater resistance of the gut to absorption and freedom from danger incident to the employment of an inflammable fluid.

2. *Non-Absorbable Ligatures and Sutures* are silk, linen, silk-worm gut, and horse hair. These can all be sterilized by boiling in water. Silk is one of the oldest suture materials, and from a mechanical standpoint it is the most dependable of the list. It is small, strong, pliant, inelastic and will not slip when properly tied. For fine, accurate work, such as intestinal anastomosis, it is indispensable, and is still used even by the most ardent supporters of the absorbable suture. Since it remains permanently as a foreign body it should not be used in pus cases when it can be avoided, for, once infected, it remains as a "dead ligature," keeping up the suppuration until removed or extruded. Catgut, which will soon be absorbed, is far preferable in such cases.

Linen, or Flax, is similar to silk and is used for the same purposes. There is a preparation of linen much in favor at present known as Pagenstecher thread. It is impregnated with celluloid, which destroys its capillarity so it will not act like a wick.

Sterilization of Silk and Linen Sutures. It is easy to sterilize silk and linen sutures as they can be boiled. The difficulty is in keeping them sterile until they are used. The secret of success lies in avoiding any undue handling of them. There is no time during an operation for threading needles, for with wet needles and wet silk it is a tedious and difficult task. The assistant should anticipate the surgeon's need and thread them beforehand.

Take an ordinary operating towel and fold it down the middle longitudinally. Thread the suture into the needle and tack it to the towel at three points, leaving the needle in the last. When four to six threads are thus pinned to the towel a quarter of an inch apart, skip an inch, proceed with the next size and so on until all are in. The towel now contains all the sutures that are to be used, with their needles in a row at the top and the sizes separated by broad spaces so they can neither become mixed nor tangled. The towel is now folded across and rolled up and pinned. This package is sterilized by boiling. Any left after an operation should be discarded.

Silkworm Gut. This is known to fishermen as grass and is seen as the long, transparent leader on fish hooks. It is the immature silk taken from the cocoon, drawn out into wire-like threads of different sizes and from 14 to 16 inches in length. They are small and pliant, with no capillarity and great tensile strength and make excellent external sutures. To sterilize them, three stands are taken and made into a coil, just as was done with the catgut. These coils are strung on a thread. The string of coils is then boiled in water for ten minutes. Finally the thread is seized with sterile forceps and the coils transferred to a jar containing a solution of 1 per cent scale iodine, 40 per cent water, and 60 per cent alcohol, in which they are kept until used. The iodine stains the white translucent strands, thus rendering them more easily seen. In addition it makes the suture antiseptic. This is an important feature now recognized as desirable in all sutures. It is not sufficient for a suture to be simply aseptic because in its passage through the skin it is liable to become infected with the staphylococcus pyogenes albus ever present in its deepest layers. In order to inhibit the growth of this germ and prevent suppuration and the development of a stitch abscess the sutures should exert a germicidal or antiseptic action.

Horse Hair makes a good skin suture where neat, accurate plastic work is to be done, as in wounds on the face. Hair from either the tail or mane may be used. It is prepared by washing thoroughly with green soap and warm water to free it from dirt, then soaking in ether for twenty-four hours to remove the oil, then making it into coils, disinfecting it by boiling and storing and rendering it antiseptic by putting it into a solution of iodine water and alcohol just as was done with the silk worm gut.

Drainage Materials and their Preparation. Drainage is employed for two purposes, to remove infected material from wounds or cavities; or, to remove such fluids as blood or serum which offer an inviting soil for bacteria and mechanically interfere with the proper healing of wounds. For these purposes, rubber and glass tubing and strips of gauze are used.

Rubber Tubing can be purchased from any surgical supply house in sizes ranging from that of a goose quill to as large as the thumb. It should be disinfected by boiling for ten minutes and kept in jars containing 1-1000 bichloride solution. If it is known that it will be employed in a given operation it should be reboiled with the instruments. Fishing it out of the jar at the last moment causes delay and endangers infection from contact with unclean edges. Before placing the rubber drain in position small holes should be clipped in the sides by doubling it on itself and cutting away the corner with scissors. It is sometimes better to bring the drain out through a separate stab incision in the skin. This enables the surgeon to locate the outlet of the drain at the most dependent part, an important point, as the tube cannot drain up hill, and also permits of the complete and immediate closure of the primary incision, a procedure which prevents complications and hastens the patient's recovery.

Glass Drainage Tubes are especially designed for draining the peritoneal cavity. They are from four to six inches in length and from one-fourth to one-half of an inch in diameter. The upper end is flanged so it cannot slip into the abdomen, while the lower inch or two is perforated with holes. When occasion requires the tube is placed so that the lower end reaches the most dependent point in the pelvis and its upper end emerges through the abdominal incision. It is aspirated as often as the cul-de-sac fills by a glass syringe with a rubber tube on its tip. Glass drainage tubes should be disinfected by boiling.

Gauze Drainage performs a function which the others cannot do. It drains up hill. It does this by capillary attraction like a lamp wick. If dry gauze or cotton is packed around a lamp wick and replenished as often as it becomes wet it will empty the lamp of oil more quickly than a flame. This must be borne in mind in using gauze drainage. Keep dry gauze and cotton on the upper end of the drain. When the gauze becomes choked with pus it stops draining and must be replaced with fresh strips.

Gauze drains are made by taking strips of plain aseptic gauze, or of iodoform gauze, and laying them parallel with each other until a drain of the desired size is obtained. The strips may be cut by a nurse but can be bought ready made on the market with woven edges so that there are no ravelings or loose threads. The strips vary in width from one-half to three inches. The advantage claimed for the iodoform gauze over the plain is that the iodoform prevents the development of saprophytic organisms and the decomposition of wound secretion. Certainly it will be found that a wound drained with iodoform gauze has less offensive odor than a similar one drained with plain gauze. Gauze strips should be sterilized by packing lightly in a glass ignition tube plugging the mouth with absorbent cotton, and subjecting to heat under pressure in the autoclave.

Rubber Dam. One of the objections to gauze drainage is that granulations grow into its meshes from adjacent tissue and render its removal at times difficult and exceedingly painful. This objection may be overcome by encasing the bundle of gauze strips with thin rubber dam, wrapping it about it as a cigarette smoker wraps the paper about the tobacco. The ends of the gauze are allowed to extend an inch or more beyond the rubber dam. This prevents adhesion of the gauze to the surface of the wound and does not interfere with its function as a drain. Rubber dam can be bought from any dealer in dental or surgical supplies. It should be prepared for use by cutting in squares 4 by 6 inches and disinfected by boiling.

Sponges are used principally to remove blood from a wound. The name is a relic of the time when marine sponges were used. Now all surgeons employ gauze as not only cheaper but safer. Sponges are made by taking a piece of gauze one-fourth of a yard square, turning in the edge and folding it into a square about 4 by 4 inches. These are put up in loose packages and sterilized in the autoclave.

Diaphragms or Gauze Towels are used to wall off or protect parts of the abdomen, to dam back the intestines out of the pelvis, and to keep exposed viscera and raw surfaces warm. They consist of four thicknesses of gauze, hemmed at the edges. They are about eighteen inches square, and have a piece of tape sewed to one corner. When put into the abdomen this hangs out and is clamped with forceps as an additional precaution against leaving it in after closure.

Dressings should be cut in convenient sizes and shapes, ready for use, so there will be no delay in applying them. If gauze is cut into rectangles 7 by 8 inches, by folding four or five thicknesses across, pads 7 by 4 inches are made which are convenient for use. The frayed ends, when packed against drainage strips, rapidly disseminate fluids through the entire dressings. A padding of these one-half inch thick is placed over the incision and fastened in position with adhesive strips. This is then covered with a pad of cotton and the whole secured with a binder or roller bandage.

Abdominal Pads are used in dressing abdominal wounds. They are made of cotton 1½ inches thick and 8 inches wide by 10 inches long. They are covered by a double thickness of gauze to prevent the cotton flying and to facilitate handling.

Perineal Pads are made the same way, only they are 8 inches long by 3 wide and 1 inch thick. With each is a T bandage to hold it in position.

Dusting Powders for clean wounds have been practically discarded. Those with iodine as a basis at times decompose, making an irritant. Others form a crust, which keeps in the secretions of the wound or prevents their removal by clogging the drainage. As good results are obtained without their use, and the powder box is one more source of possible contamination in the operating room.

LECTURE XLVIII.

ASEPTIC SURGICAL TECHNIQUE (CONTINUED)—PREPARATION OF PATIENT FOR OPERATION—PREPARATION OF OPERATING ROOM AND ACCESSORIES—AFTER CARE OF PATIENT—TECHNIQUE IN COUNTRY PRACTICE.

III. THE AFTER CARE OF THE PATIENT.

When the operation is concluded, the dressing applied, and the gown, if soiled or wet, changed, the patient is ready to be taken to his room. To accomplish this would seem a simple procedure, yet from the lack of definite plan it is often the occasion of much confusion and delay. The litter consists of a light frame of metal tubing resting on a rolling carriage. The frame is short enough to fit lengthwise in the patient's bed. The litter is covered with a warm, dry blanket. It is rolled up beside the operating table. Two assistants on the opposite side of the table now lift the patient vertically upward while two others slip the frame beneath him. The blanket worn around the limbs during the operation is removed and the blanket on the litter wrapped about him. The frame is put back on the carriage and the patient quickly rolled to his room. The frame is put on the bed, the patient lifted up and frame slipped out. The transfer is complete and there has been no pulling or hauling, which might slip a ligature or disarrange the dressing. A nurse must now sit with the patient until the effects of the anesthetic have worn off and reaction has taken place.

Shock is rarely seen in an alarming degree after operations on carefully prepared patients, planned and executed so as to avoid unnecessary loss of heat, blood and time. It is frequently seen, however, in accident cases, especially if there has been hemorrhage or mutilation.

The operating room is not the place to treat shock. Only in rare cases should intravenous or subcutaneous transfusion be practiced while the patient is on the table. The unavoidable delay in the operation, the danger of infection and the manipulations of unskilled assistants which attend the procedure render it more productive of harm than of good. All that should usually be done is to give a hypodermic of a small dose of morphine and bend every energy to the rapid completion of the operative work and the early removal of the case from the table. The patient should be put to bed between warm blankets. Additional heat should also be applied by means of hot water bags, care being taken to prevent accidental burns. The foot of the bed should be elevated to allow blood to gravitate to the anemic brain. The half empty blood vessels should be filled by the introduction into the system of as much normal saline solution as it will take up. This can best be effected by low pressure continuous rectal injection. By this method many quarts of fluid can be introduced without discomfort or traumatism.

While the use of small doses of morphine has a decided effect for good, the confidence formerly placed in strychnine seems misplaced. If shock is due to paralysis of the vasomotor system the stimutalion of the exhausted centers will result in more harm than good. Of all drugs employed to produce reaction, the solution of chloride of adrenalin seems the most logical. As its effect is evanescent the doses must be repeated at frequent intervals. In addition to the measures recommended it is of the utmost importance to exclude all relatives from the room, thus removing injurious excitement. The patient should not be encouraged by hysterical reassurance, but made to feel that everything is being done for him by the quiet self-confidence exhibited in the deportment of the doctor and nurses.

Pain. The first, and to the patient, the most important symptom after an operation, to demand prompt and adequate treatment, is pain. It is often a difficult question for the surgeon to decide how much the patient really suffers, and what measures are really demanded. Some patients make a great outcry, when really they are more scared than hurt, and the pain will do them less harm than the drug that brings relief. Again other patients invested with a sort of old-fashioned doctrine of predestination, will make no complaint and it is only by seeing the set face, the compressed lips and clinched hands, and noting the cold and clammy skin, that a knowledge is derived of the necessity of giving an opiate. When pain is moderate the patient should be encouraged to bear it, but when it is excessive the patient should be relieved by the hypodermic use of morphia. The bromides and coal tar preparations are useless. Morphine in small and, if necessary, repeated doses is what is demanded. It is true the drug may mask symptoms, cause nausea and produce constipation, but it is the lesser horn of the dilemma. In the old days morphine was first abused and then not used. Even now some well-known authorities decry its employment. The majority of modern surgeons, however, believe that, when administered judiciously, it not only brings temporary relief but frequently saves life.

Nausea. Another frequent and distressing symptom from which the patient suffers after an operation is nausea and vomiting, primarily due to the anesthetic, but sometimes continued by sepsis and the presence of blood and bile in the stomach. When the patient retches on the operating table and it is evident there is fluid in the stomach, much after distress will be avoided if the stomach is emptied and rinsed before he is taken to his room. This procedure is a routine practice with some surgeons, but is not necessary or advisable in all cases. When nausea and vomiting continue it is at first treated tentatively by putting ice cloths to the head and throat, applying a mustard plaster to the pit of the stomach, and giving cracked ice, or a few sips of water. If the symptoms are unrelieved the patient is given two glasses of tepid water. Is is always taken with relish. If retained it re-establishes peristalsis in the proper direction, and if rejected it washes out the stomach almost as effectually as could be done by lavage. Drugs, such as creosote, oxalate of cerium, ingluvin, bismuth, hydrocyanic acid, etc., have been found useless, and the effervescent drinks, such as ginger ale and champagne, are positively injurious. In the vast majority of cases the nausea will cease spontaneously as soon as the chloroform or ether is eliminated from the blood. This is the only panacea, and unless symptoms of sepsis are evident, the less that is done by the surgeon, the sooner the patient will experience relief.

In a few cases the vomiting, instead of getting better, gets worse. At first the patient strains violently and ejects a clear or yellow fluid. Later, without muscular effort, there is the constant regurgitation of a green or black fluid. There is little or no nausea, but at frequent intervals the patient gives a little gulp and spits out a mouthful of what is popularly supposed to be bile. A chemical examination will show that it is not bile but blood. The pathology of this condition is a disputed question, but it is generally believed that a low grade of septicemia has so weakened the gastric blood vessels as to permit of hemorrhagic transudation. The practical fact is that if these patients are let alone most of them will die. The introduction of a stomach tube will show the presence of a quart or more of black fluid in the stomach. What is spit up is merely the overflow. If the material remains in the stomach the patient will die from exhaustion. If the material passes into the intestines the patient will die from toxemia. The prompt use of the stomach tube at the first symptom of black vomit, the emptying of the viscus and the irrigation of its cavity with normal saline or a weak adrenalin solution gives the only chance of life.

Position in Bed. In the early days of abdominal surgery patients were kept on their backs and not allowed to turn on their side for the first seven days. It was found, however, that, in addition to the sufferings entailed, there was an increase in the liability to adhesions. After an ovariotomy or hysterectomy it is well to keep the patient in one position for the first twenty-four hours to lessen the danger of a ligature slipping, but in operations like appendicitis the patient should be encouraged to lie first on one side and then on the other. In cases of operations on the stomach or where there is a vaginal drain, the patient should be put in an exaggerated Fowler's position in order to carry fluids in the desired direction by gravity. Some surgeons go so far as to put all laparotomies in a sitting position from the first, claiming not only better drainage, but increased freedom of respiration from the removal of the pressure of the liver on the diaphragm. The position of the patient in bed is the essential feature of the modern method of treating cases of diffuse suppurative peritonitis, hence hospitals should have facilities and nurses experienced to enable them to handle such cases.

Bladder and Kidneys. During the first few days after an opertion the bladder and kidneys require careful watching to see that they properly perform their functions. If the patient does not voluntarily pass urine he should be urged to make every effort to do so. A catheter should not be employed if it is possible to avoid it, as its use always entails some danger of infection, and makes the patient more or less dependent on it in future. Sometimes, however, it has to be employed to prevent undue distention of the bladder. The quantity of urine should be carefully recorded, and if any abnormality is noted a specimen should be sent to the laboratory for examination.

In cases of chronic nephritis and in cases of acute septicemia and cholemia there is often sudden suppression of the urine which may result in death. After operations on patients with jaundice more cases die from uremia than from any other one cause. At St. Luke's Hospital the old treatment by transfusion, sweating, cups over the kidneys, administration of infusion of digitalis, etc., has given very poor results. Recently a new line has been followed, and it is believed that a distinct improvement has been made. As soon as any inadequacy of kidney activity is noted, sulphate of spartein is given hypodermically in one or two grain doses; repeated according to effects at four or six hour intervals. In many cases where there was complete suppression there has been prompt response to the drug with ultimate recovery.

Bowels. When peritonitis, either local or general, was more the rule than the exception after abdominal sections, it was the practice to give calomel in large doses as soon as the stomach would retain it. In fact the surgeon was not happy until the patient was freely purged.

That early purgation is a prophylactic against inflammatory conditions is undeniable but that it depletes the patient, retards recovery, and is not necessary under modern methods has been proved to the satisfaction of most operators. In a case which runs smoothly—in other words, when the abdomen is not distended and the pulse and temperature are practically normal, there is no hurry to purge. Usually a soapsuds enema is given 36 to 48 hours after the operation and the bowels afterwards regulated if necessary by the administration of some mild laxative, such as cascara or senna. Occasionally, however, symptoms quickly develop which forbode evil, and then broken doses of calomel should be at once prescribed. Should the drug be rejected, or fail to act, it should be followed by enemata. When the abdomen becomes swollen and tympanitic the administration of purgatives by the mouth should be withheld. The bowels are paralytic from distention, and stimulation is ineffective and harmful. In this condition enemata are the sole reliance. Many authorities recommend high injections through a long rectal tube, but this method has not given the results that were claimed for it. In the hands of the average nurse, the tube coils up in the rectum, and the surgeon himself usually fails in his efforts to pass it through the sigmoid flexure. Fortunately the slow injection into the rectum with an ordinary syringe gives about as good results and does not entail as much manipulation or cause as much discomfort. The formula of the enemata used varies, the most common combination consisting of glycerine, turpentine, sulphate of magnesia and water. Hardon, of Atlanta, is enthusiastic in advocating a mixture of one ounce of powdered alum to one quart of water and at St. Luke's Hospital human bile is sometimes used with good effect. This is only possible when a case of gall-bladder drainage is in the house to supply the needed material. For the past ten years efforts have been made by many experimenters to find a drug which would produce purgation when administered hypodermically but so far without success. If such an agent is ever discovered it will prove one of the most valuable additions that could be made to our present resources. Physostigmine salicylate is popular for this purpose.

Water. As an empty stomach is one of the best safeguards against vomiting, water should be withheld from a patient for several hours after recovery from anesthesia. If at the end of this time no nausea exists it may be given in small quantities at half-hour intervals, and if it be well borne by the stomach the quantity increased until thirst is relieved. The water may be acidulated with lemon juice or cold or hot tea, without sweetening, substituted for it. Should vomiting prevent the patient from retaining fluid, thirst may be relieved by allowing the patient to rinse out the mouth with water to get the taste, and injecting a pint of saline solution in the rectum to produce the effect.

Nourishment. If the patient is very weak, nutritive enemata may be use from the first. In employing this method of feeding it must be remembered that while the rectum can absorb it cannot digest, hence nutriment must be in an assimilable form. As good a mixture as any other consists of two ounces of peptonoids or predigested beef and four ounces of saline solution. If deemed necessary one ounce of whiskey may be added. Nutritive enemata should not be given any oftener than every six hours, and the rectum should be irrigated once daily to remove residuum or other irritating material. The average patient does not require any nourishment for the first twenty-four or thirty-six hours—in fact may be safely and advantageously allowed to go without food for two or three days. Dr. Tanner has taught the profession that starvation is not an immediate danger. The case whose death is attributed to exhaustion, usually dies from some form of sepsis.

The first nourishment given a patient by mouth should be liquid, easily digested and not likely to cause gas in the stomach and intestines. Egg albumen, chicken broth, beef tea and buttermilk fulfill these conditions. After the fourth or fifth day, if everything is going well, soft boiled eggs, milk toast and other semi-solid articles of diet may be added. At the end of the first week the patient may be allowed the ordinary hospital bill of fare.

Tonics. But little medicine as a rule is given in a surgical hospital. If the patient's appetite flags a tablespoonful of whiskey before meals or a glass of wine or beer with meal is usually more productive of results than distasteful drugs. If the patient feels he is being neglected he should be given tincture of nux vomica or some harmless placebo, with which the market is well supplied.

General Hygiene. The efficiency of the modern trained nurse leaves little for the surgeon to suggest in regard to changing bed linen, giving baths, rubbing the back, etc. If there is one point occasionally neglected it is the toilet of the mouth. The proper use of the tooth brush and the employment of antiseptic washes will not only add to the patient's comfort, but prevent fermentation of food by the reduction in the number of bacteria taken into the digestive tract.

Length of Confinement to Bed. It is of course impossible to have any hard and fast rule as to how long it is necessary to keep a patient in bed after an operation. Each case must be considered on its special indications. A prudent patient may be allowed to sit up sooner than a reckless one. A lean individual will secure a firm cicatrix quicker than a fat one. A wound that unites by primary intention does not necessitate the same length of confinement as one that suppurates. Still there ought to be some consensus of opinion among surgeons of experience as to how long an uncomplicated abdominal case should retain the recumbent position. Unfortunately the beginner who consults literature for the answer to this question will find the expression of different views. Some surgeons put their appendicitis case up on the seventh day and send them home on the ninth. Others keep them in bed three weeks and discharge them, with many injunctions as to prudence, a week or ten days later. The tendency is to make the patient's stay in the hospital shorter and shorter. This is partly due to improved results, but also influenced by a desire to advertise the surgeon, to make the patient more willing to consent to an operation, to increase the number of cases cared for by a ward of limited capacity, and finally to lessen the money paid to the hospital so that there may be more left for professional services. Between too great conservatism on the one hand, with the attendant loss of time and money, and too great radicalism on the other with the danger of hernia and other complications, there must be eventually derived the happy mean. At present the average surgeon keeps appendicitis cases in bed about two weeks and discharges him in three. An operation necessitating great weakening of the abdominal wall such as hysterectomy confines the patient to bed three weeks and to the hospital four. Experience has proved that incisions in the upper abdomen for liver and stomach work do not entail the same liability to hernia as openings in the lower abdomen for pelvic tumors; hence the time in bed after the former may safely be less than after the latter. The use of abdominal belts after an operation is not advisable unless the abdomen is pendulous, or in cases where the cicatrix is weak owing to the employment of drainage. This last indication for the use of an irksome prophylactic measure has been materially lessened by the present practice of inserting drains, when needed, through stab incisions and closing the operative wound as if no drain had been employed.

The After Cure of Wounds. Clean wounds, without drainage, need not usually be dressed until the eighth or ninth day, when the stitches are removed and a second dressing applied. These three indications for an earlier dressing are pain, fever, or saturation of dressings with wound secretion. Should the wound be uncomfortable when there is no rise of temperature it is probably due to stiffening of the dressings with blood or serum, and redressing will give immediate relief. Should there be a tight stitch with a red area about it, it should be clipped or removed as soon as discovered in order to prevent the formation of an abscess.

Clean Wounds, with Drainage. These wounds should be dressed as often as the dressings become saturated. Such cases as amputations of breasts or limbs in which there is oozing of blood should have the drain removed as soon as it has ceased to perform its function. This is usually at the end of forty-eight hours. Rubber tubing slips out without pain, and gauze if removed slowly will not give a great deal of suffering.

Infected Wounds with Drainage. The problem to be solved in these cases is to provide for the escape of the morbid products until the wound or cavity is filled with new tissue; hence we cannot reduce to days or hours the time that drainage should be kept in. Pus will quickly clog the meshes of gauze; so it becomes necessary to remove and replace it daily in order to obtain the best results. The question of when to remove abdominal drainage is often asked, and is difficult to answer. The strips of gauze are placed with their end over the focus of infection or into the most dependent part of the abdomen. During the first twenty-four hours the serous drainage is profuse, becoming less and less. In forty-eight hours the intestines, by adhesions, are walling off the peritoneum and forming a plastic canula around the drain. Removal now might break up this wall and reinfect the general cavity. In five or six days there is little danger of breaking up this wall, and the gauze lubricated with pus will slip out more easily than earlier. The tendency is to remove the drain too soon. In many cases it may safely be left in place for a week. When the primary drain is removed a smaller drain is substituted and this is removed and replaced daily until cessation of discharge makes it no longer necessary to do so.

Technique of Dressing Wounds. That there may be no time lost in needless delays a perfect system of wound dressing is imperative in a well ordered hospital. A tray is fixed to dress each wound and it should contain every article that is needed. A clean towel covers the tray and upon this are the following articles:

1. An ordinary grocer's paper bag.
2. A pair of bandage scissors.
3. A spool of adhesive plaster.
4. A package of sterile cut gauze.
5. A package of cotton or pads.
6. Ignition tube containing drainage strips.
7. Two sterile towels.
8. A basin of 1-1000 warm bichloride solution.
9. Instrument tray containing a pair of sharp pointed scissors, a probe and dressing forceps.

The nurse places this tray on a bedside table, lets in plenty of light, fixes the gown and bedclothes, removes the external dressings and unpins the sterile packages. The dresser with clean hands removes the remaining dressings. The soiled dressings are put in the paper bag which is burned in the furnace as soon as the case is finished. The wound is next protected from the bed linen with sterile towels and bathed with bichloride solution. Stitches are removed, drainage replaced when necessary and a fresh dressing applied. In order to save the dresser's hands from repeated washings in bichloride, and to prevent them from becoming contaminated, rubber gloves should be worn in dressing wounds. To prevent the possibility of infecting one wound from another, clean wounds should always receive the first attention.

IV. Technique in Country Practice. The preparation for an operation in a city residence does not vary materially from that of a hospital. The surgeon's satchel contains every needed article. The instruments and sutures are all selected for him; the other necessities are listed and packed in the least possible space The packages are sterile and sealed; the outfit stands ready to leave at a moment's notice; the preliminary preparations are made by trained assistants who take pride in their work.

The problem that confronts us is, how may good clean work be done in the country without the aid of the accessories of a hospital or the assistance of its staff. The operator must first master the principles of hospital technique. He must have in his mind the model of an operating room, and arrange the position of each table and bowl and pitcher according to this plan. Spare hours could not be better spent by a student or a graduate than in actually preparing such a room for an imaginary patient. Practice alone can make one quick and skillful, and nothing give confidence so surely as seeing such preparations proceed as though they were an every day occurrence.

The Essential Materials and Implements to be brought by the surgeon are chloroform, alcohol, bichloride tablets, green soap, scrubbing brushes, razor, Kelly's pad, gauze, cotton and bandages. These should be kept packed in a satchel by everyone who expects to do surgery. The necessary instruments, sutures and drainage materials can be quickly selected with reference to the case.

The Room in which the operation is to be performed should be chosen with a view to the space and light it affords and the ease with which it can be heated. Obstructive furniture should be removed, but no change made which creates dust. If the room be carpeted a sheet is spread over the floors. A pine kitchen table, two small bedroom tables placed end to end, or a window shutter on two flour barrels will make a good extemporary operating table. By hanging the patient's knees over the end of a kitchen table and putting the two legs of the table on chairs a fair Trendelenburg position can be secured.

The operating table should be covered with a folded blanket and a sheet, and placed with its foot to the window which is to be the source of light. On its right should be a table for instruments, on its left a table for sponges, and beside it a third table or chair for materials to be used in preparing the site of incision. A washstand should be conveniently located for scrubbing the hands. A bureau will make a good stand for solution basins. All these should be covered with sheets, not alone for the sake of cleanliness but also because the unusual sight serves to keep them from being molested by untaught but too willing hands of relatives.

Materials to be Procured from the Household. Basins, trays, etc., must be selected from the domestic crockery. Ordinary wash bowls answer well for hand basins. China vegetable dishes make good containers for sponges. A wide mouth pitcher will serve as an excellent plunge bath for the hands; smaller pitchers are useful for solutions. A meat dish makes a good instrument tray. Saucers and butter plates can be used for ligatures and needles. Two milk pails will act as reservoirs for hot and cold water. A sauce pan or kettle can be used as an instrument boiler. Slop jars or tin foot tubs will serve to catch waste water. Needless to say the linen closet should also be levied on and the available supply of clean towels and sheets appropriated.

Hot and Cold Water. For the first washing of the hands and for the preparation of bichloride solutions to disinfect crockery, linen, etc., ordinary spring or well water can be used. But for final ablutions and actual contact with the wound a limited amount of boiled water must be provided. As the heating and especially the cooling of water takes more time than any other step of the preparation, it must be the one first seen to. Two clean tin buckets are selected and filled two-thirds full of clear water. They are put on the kitchen stove and a hot fire maintained until they boil. One is left on the fire to keep hot, the other taken off to be cooled. This can be rapidly accomplished by setting it in a wash-tub containing cold water and changing the water in the tub as soon as it becomes warm. It is well to have a dipper, which can be boiled in one of the buckets, to be used in dipping out the hot and cold water to make solutions of the desired temperature.

Sterilization. When the furniture in the room has been set in order and the materials are all at hand, the tables are covered with sheets and the work of sterilizing begun. First a sheet apron is put on and then the hands are scrubbed at the wash-stand as described in hospital technique. Next each basin, dish and pitcher is washed with green soap and water, and immersed in a 1-1000 bichloride solution. The solution bowls are put side by side on the bureau and filled with alcohol, bichloride solution and sterile water. The vegetable dishes are filled with boiled water and put on the sponge table. Liquid green soap, alcohol, gauze mops, a razor and two pitchers containing bichloride solution and sterile water are put on the scrubbing table or chair. In all the foregoing the clean worker should be assisted by some-one whose hands have not been sterilized.

Instruments, Sponges, Towels and Dressings. While the above preparations are going on the instruments have been boiling in a pot on the kitchen stove. In case the operator has no sterile packages of sponges, dressings, or towels, he has made two or three dozen gauze pads, 4 by 4 inches, and boiled them in towels with the instruments. The pot is brought in and set on the floor. The operator now sterilizes his hands, covers the instrument table with boiled towels and sets all his instruments and sutures in order. The sponges are put in one of the sponge bowls, and the patient is brought in and anesthetized unless this has been done in an adjoining room.

Preparation of the Site. When under the anesthetic the patient is put in the Kelly's pad and the site shaved and scrubbed with green soap, and sterilized with alcohol and bichloride solution just as in the hospital case. A sheet is now fixed to cover the body except the area to be operated on. The field is protected by towels which have been boiled or wrung out of bichloride. The surgeon and his assistant again sterilize their hands and the operation begins. The operator picks up his own instruments and the first assistant in addition to his other duties attends to the sponge table. When the operation is completed boiled gauze can be put next to the wound and dry gauze and cotton placed over it. The after care of the patient and the wound does not differ from details previously described.

LECTURE XLIX.

ANESTHESIA AND ANESTHETICS—GENERAL AND LOCAL ANESTHESIA—VARIOUS DRUGS EMPLOYED, WITH THEIR THERAPEUTIC ACTION, INDICATIONS FOR USE, METHODS OF ADMINISTRATION.

HISTORICAL.

The Assyrians used digital compression of the carotid artery to produce insensibility during the operation of circumcision. The Egyptains administered Indian hemp and the juice of the poppy to dull pain. The Jews relieved the death agony of criminals during crucifixion by applying a sponge to the face saturated with "the wine of the condemned." The Arabians used mandragora. Isidorus, one of their writers, says: "wine of the bark is given to those about to undergo operations, that, being asleep, they feel no pain." The Hindus administered the fumes of burning Indian hemp. The ancient Chinese gave a preparation called Ma-yo, which caused patients to become insensible.

The Monks, during the Middle Ages, produced anesthesia by causing patients to inhale the odor of a "sleeping sponge." The following is found in a book of the sixteenth century: "Take of opium, mandragora bark and henbane root equal parts. Pound them together and mix with water. When you want to sew or cut a man, dip a rag in this, and put it to his forehead and nostrils. He will soon sleep so soundly that you may do with him what you will. To wake him, dip the rag in strong vinegar."

References to anesthesia and anesthetics are frequent in the writings of Shakespeare and other authors. Dubartas, in 1592, says:

> "Even as a surgeon minding oft to cut
> Some cureless limb, before in use he puts
> His violent engines in the victim's member,
> Bringeth his patient in a senseless slumber;
> And griefless then, guided by use and art,
> To save the whole, saws off the infested part."

In the seventeenth and eighteenth centuries it became a common practice, before operation, to drug patients with narcotics to allay pain and prevent shock. About this time great interest was taken in mesmerism and hypnotism, and repeated instances are on record where severe and prolonged operations were performed without pain to the patient by throwing him into an artificial sleep or trance. It was found, however, that the methods were uncertain and dependent on the susceptibility of the individual case.

We now come to the anesthetics of the present day, and the history of the discovery of ether will be traced at some length, as every student should know the facts, for, while there is a question as to whether the credit be due to Long, to Jackson or to Morton, there is no doubt that it is due to an American.

As soon as Priestley discovered oxygen, various investigators made many experiments with it and other gases. J. Marion Sims relates the following incident which occurred in 1839. A number of half-grown boys in South Carolina were diverting themselves by inhaling ether. Becoming intoxicated, they seized a negro who was watching their antics and compelled him to take the drug by holding a saturated handkerchief over his nose. At first his struggles were amusing, but soon he became unconscious, had stertorous breathing, and his condition caused great alarm. After an hour or two he recovered and was none the worse for his experience.

Three years later one of the participators in the affair became the pupil of Dr. Crawford W. Long, of Georgia. He called Dr. Long's attention to the effect of ether, and they began to experiment on each other. In March, 1842, Long persuaded a patient on whom he was about to operate for a small tumor to inhale ether, and the operation was completed without pain. The record on his ledger reads: "James Venable, 1842, —Ether and Excising Tumor, $2.00." During the year he did four other operations in the same way, and repeatedly used ether as an anesthetic in 1843 and 1845. His work was known to neighboring practitioners, but was not published: hence the dispute which subsequently arose as to his right to priority in the discovery of anesthesia.

In 1844, Dr. G. Q. Colton gave a lecture at Hartford, Conn., on nitrous oxide gas. A dentist named Horace Wells was present, and immediately saw the possibility of using it as an anesthetic. The next day he induced Dr. Colton to give him the gas, and while under its influence he had a tooth extracted. When he regained consciousness, he said—"This is a new era in tooth-pulling." He gave nitrous oxide gas to several of his patients, and shortly afterward went to Boston to give a demonstration at the Massachusetts Hospital, but for some reason it was not a success, and he was denounced as an impostor. Later, his mind became deranged, and at the age of thirty-two, he committed suicide while confined in a New York jail.

In 1846, W. G. T. Morton, of Boston, a dentist and a former partner of Horace Wells, began to investigate various narcotics in an effort to find a better agent than nitrous oxide gas to produce anesthesia. At the suggestion of Charles T. Jackson, a chemist, he experimented with sulphuric ether. He inhaled it personally and lost consciousness for seven minutes. He then gave it to several patients, and extracted teeth without pain. He finally went to Dr. John C. Warren and obtained permission to try the anesthetic at the Massachusetts General Hospital. On October 16, 1846, Morton, in the presence of a large number of medical men, gave ether to a patient who was operated on by Dr. Warren. The administration was a complete success and created interest and enthusiasm. Morton, for a time, refused to disclose the nature of the agent he used. He called it "Letheon," and disguised its color and odor by the addition of dyes and aromatics. He offered to go into partnership with Jackson, who shared his secret, and to put it on the market as a patent medicine. Finally, however, becoming convinced that the medical profession would not use the agent unless they knew its composition, he announced the fact that it was simply sulphuric ether.

Oliver Wendell Holmes coined the words "anesthesia" for the condition and "anesthetic" for the agent, both of which are now in universal use throughout the world.

A dispute immediately arose between the friends of Morton and Jackson as to who was entitled to the credit of the great discovery. When their rival claims were presented to Dr. Holmes, he proposed that a monument be erected to Painless Surgery, with the statue of Jackson on one side, of Morton on the other, and the inscription: "To E(I)THER." Morton spent his life in contentions and disputes, and died at the age of forty-nine, broken-hearted and bankrupt. Jackson, like Wells, became insane, and died in an asylum in 1880.

A dispassionate review of the evidence seems to show that Long, of Georgia, unquestionably discovered and employed ether as an anesthetic four years before Morton's demonstration in Boston. Owing, however, to his failure to publish it and to the remoteness of the district in which he lived, his work was unknown and would probably have died with him. Between the claims of Jackson and Morton to the discovery of ether, it may be said that Jackson supplied the inspiration, while Morton practically demonstrated the fact.

The use of ether as an anesthetic was immediately taken up in Great Britain and on the Continent. Sir James Y. Simpson, of Edinburg, was the first to employ it in obstetric practice. Owing to the fact that several deaths were reported and that its odor was disagreeable and persistent, he began to search for another and better agent. Waldie, a chemist, suggested the use of chloroform, and Simpson tried it and soon became convinced of its superiority. In November, 1847, he published a paper: "Notice of a New Anesthetic Agent as a Substitute for Sulphuric Ether."

In 1884, Karl Koller, of Vienna, demonstrated the power of cocaine to produce local anesthesia. Eucaine, stovaine, nova cocaine and other substitutes have since been introduced.

ETHER.

Ether, $(C_2H_5)_2O$, is a clear, colorless, volatile liquid, having a disagreeable, pungent odor, and boiling at a temperature of 95° F. Its gas is two or three times as heavy as air, and is very inflammable: hence there is danger in using the agent in a room with an open flame, such as lamp or gas light, or a wood fire or oil stove.

Ether maybe administered bya special apparatus such as Allis' inhaler, but the growing tendency is to give it by the open or drop method, which consists in placing a number of layers of gauze over the patient's face, and dropping the ether on it at a rate regulated by the effect produced. The first result is to cause irritation of the larynx and trachea, producing a cough. This soon passes off and is followed by a stage of primary anesthesia which lasts two or three minutes. The face is flushed, the respiration hurried, and the pulse quick and bounding. A stage of excitement often follows, in which the patient struggles, becomes rigid, and talks or sings. This finally gives place to general muscular relaxation, complete unconsciousness and insensibility to pain. The breathing is regular and often stertorous. Ether is at first a stimulant, but later a depressant. The immediate danger of ether is from respiratory failure, which should be combated when threatened by discontinuing the anesthetic and the use of artificial respiration and administration of oxygen. The remote dangers are congestion of the kidneys with suppression of urine, or irritation of the lungs, followed by bronchitis or pneumonia.

CHLOROFORM.

Chloroform, ($CHCL_3$), is a clear, colorless, volatile liquid, of sweetish taste and pleasant odor. It boils at 142° F., and its gas is only slightly inflammable. If exposed to an open flame, it becomes decomposed and liberates free chlorine, which causes headache and nausea to the occupants of the room.

Chloroform is usually administered on Esmarch's inhaler, which consists of a wire frame covered with a single layer of porous woolen cloth. A few drops of chloroform are put on the inhaler, which is held some distance from the patient's face. The inhaler is gradually brought nearer as tolerance is acquired to its effect, but the vapor of chloroform should always reach the patient well diluted with air. It is claimed that anesthesia is quicker and more pleasant if the chloroform is warmed by placing the bottle occasionally in warm water.

The effect of chloroform is at first to dilate the pupil and to stimulate the pulse. The patient soon becomes excited and acts as if under the influence of an intoxicant. As this stage passes off, the pupils contract, the pulse becomes somewhat weaker, and the face loses its color. The breathing becomes deep and regular, and there is unconsciousness, general muscular relaxation and complete insensibility to pain. The greatest danger from chloroform is sudden cardiac failure, although numerous deaths have been reported from its action on the respiratory centers. When dangerous symptoms develop during anesthesia, the drug should at once be withdrawn, an abundance of fresh air admitted to the room, the head of the operating table lowered, and artificial respiration practiced, coupled with inhalation of amyl nitrite. Artificial respiration is best effected by Sylvester's method, care being taken that the motions are not carried out too rapidly, and that they are sufficiently exaggerated to insure expansion and contraction of the chest walls. Hypodermic injection of strychnine or other drugs is useless, as the danger is too imminent for there to be sufficient time for the system to be affected in this way.

RELATIVE MERITS OF ETHER AND CHLOROFORM.

The question of the relative merit of ether and chloroform is one which has caused bitter and, often, unprofitable debate. It is a fact that surgeons inherit their advocacy of one or the other agent, just as they inherit their political principles or theological belief, and it is as hopeless to try to convert an advocate of ether to chloroform as it would be to change a Republican to a Democrat or a Baptist to an Episcopalian. In America, the North and West give ether practically to the exclusion of all other anesthetics, while in the South, chloroform is the favorite agent employed. As the most prolific writers and brilliant clinicians live in the North, there is a tendency in the South among the younger generation to either adopt their teaching, or else to apologize for the use of the anesthetic of their forefathers. In justice to chloroform, it must be said, however, that it is still the favorite anesthetic with surgeons the world over, and is, today, given twenty times where ether is given once. In France, except in the city of Lyons; in Germany and Austria, except in the city of Vienna; in Italy and in Great Britain, chloroform or a mixture of chloroform with other agents is practically universally employed. Chloroform is also exclusively used in tropical countries, but here there is no choice, because ether, with its low boiling point, cannot be employed.

There is no question that chloroform is more pleasant to the patient, is quicker in its action, causes less nausea and vomiting, and is not as likely to be followed by nephritis or pneumonia. Anesthesia can be produced and maintained with a smaller quantity, and hence the agent is cheaper and more easily transported. Its vapor is not inflammable and it can be used without danger in the presence of an actual cautery or an open flame. The advocates of ether admit all these facts, but claim that they should not be taken into consideration, as the question is not one of esthetics or economy, but of life or death, and that it has been successfully demonstrated that ether is safer than chloroform. They claim that chloroform causes one death in every 2500 cases, while ether only causes one death in every 8000, and, therefore, is three or four times safer than chloroform. Statistics from numerous and reliable sources in the North and West seem to conclusively prove this statement as far as that territory goes, but figures in the South, in Great Britain, and on the Continent are different. Nussbaum has seen in military life 40,000 administrations of chloroform without an accident. Hunter McGuire reports 28,000 administrations in the Confederate Army Corps of which he was a Director, without a fatality, and I, in private practice, have been present at 15,000 operations done under chloroform anesthesia, without a death from its use. These figures could be extended, but they are sufficient for the purpose.

After much thought and observation, I have come to the conclusion that while certain classes of cases take one anesthetic better than the other, provided they are administered equally skillfully, that for practical purposes, it is the anesthetizer and not the anesthetic who should be considered. In visiting the clinics of the North and occasionally seeing the administration of chloroform, I have ceased to wonder why sometimes patients die, and am surprised that any of them live. While again, in my travels South, I am struck by the timid, inefficient way in which ether is administered in the few cases it is employed, and marvel that the surgeon, after completing the unsatisfactory operation on a struggling patient, should ever use the agent again.

No one man, in my opinion, is competent to give both ether and chloroform. The end to be accomplished is the same in each, but the method of administration and the symptoms of danger are absolutely different, that he might as well try to attain salvation by attending a Jewish synagogue one week and a Catholic cathedral the next. In my private hospital, I use chloroform almost exclusively. In my public clinic, I employ both agents, but have a different man, especially skilled in the administration of each. In my out-of-town work, when asked which I prefer to be given the patient, I always reply, the one with which the anesthetizer is most familiar.

GENERAL RULES FOR THE ADMINISTRATION OF ETHER AND CHLOROFORM.

The administration of an anesthetic is an art acquired by practice, and no one can be taught it except by experience. The following suggestions are selected from various authorities, or are the result of personal observation.

The patient's stomach should be empty, but his resistance not weakened by long fasting. The last meal should be taken from four to six hours before the operation. The bowel should be emptied by a purgative given the night before, or better, thirty-six hours prior to the administration of the anesthetic, followed by an enema or saline the morning of the operation.

When possible, the anesthetizer should see the patient prior to the administration of the anesthetic. This tends to increase the confidence of the patient in the anesthetizer, and affords the anesthetizer an opportunity to observe the normal respiratory and circulatory movements of the patient.

Morphine should not be given as a routine practice before the administration of every anesthetic. It may be given with advantage, however, if the patient is nervous or frightened, if he is addicted to opium or alcohol, or if he is likely to suffer great pain on recovering consciousness.

If stimulants such as strychnine or whiskey seem indicated immediately before the operation, they should be given either hypodermically or by rectum: nothing should be given by mouth.

The patient should be lightly and loosely clad, with no constriction around the chest or waist to impede respiration.

The anesthetic should not be administered until it is certain the surgeon will be ready to begin the operation as soon as the patient is in condition. If either surgeon or patient has to wait, humanity demands that it be the surgeon: time to him may be money, but time to the other may be life.

In moving a patient after he is anesthetized, care should be taken to see that the head is kept in the proper position, and the respiration and heart action not interfered with.

The anesthetizer, before giving the anesthetic, should see that provision is made for the prompt admission of fresh air into the room, and that other restoratives are at hand, in case the patient does badly. Drafts and exposure should be avoided, the patient kept warm and body heat maintained.

The room in which the anesthetic is given should be kept perfectly quiet, and all instruments and apparatus likely to frighten the patient should be kept carefully out of sight.

The ether or chloroform employed should be the purest obtainable: it should be the product of well-known and reliable manufacturers.

An anesthetic should never be given except in the presence of a third party. This is especially true when the patient be a woman, as sexual excitement is often produced, resulting in the belief that improper liberties have been taken.

An anesthetic should never be given with the patient in the sitting posture, but the patient should be lying comfortably, flat on his back, with only a small pillow under his head.

The mouth should always be examined, and false teeth, quids of tobacco, chewing gum, whistles, buttons or other foreign bodies, if present, removed.

The patient should be told to close his eyes, as the vapors of the anesthetic agent may be irritating, and also because it prevents the anxious watching of each movement of the anesthetizer.

The anesthetizer should talk pleasantly and encouragingly to the patient when beginning the anesthetic, at first diverting the attention by discussing some subject of interest, and later telling the patient that he is becoming drowsy, that he is losing conciousness, that he is asleep; in other words, use hypnotic suggestion.

Never tell the patient to count or breathe deep, for by so doing a feeling of suffocation is sure to follow and the patient is apt to struggle or become boisterous.

When the anesthetic is begun, the patient should be free to move his arms and legs. Should he hold his breath until the veins become turgid and prominent, the anesthetic should be withdrawn until the breathing becomes normal. Should he become excited and struggle, it is better not to attempt to absolutely restrain his movements, but rather to guide and control them so as to prevent him throwing himself from the table. As he becomes unconscious, he should be held in position by manual force, and later he should be fastened with bandages or straps so as to keep him in position.

As to the rate of administration, chloroform should be given slowly, with free admixture of air. Slow etherization possesses no advantages and frequently prolongs the stage of excitement.

There is no certain way to tell when the patient is sufficiently under the anesthetic for the surgeon to begin the operation. The best test is relaxation of the jaw. The eye reflex is of little value, and the practice of touching the conjunctiva to see if the patient will wink should be prohibited.

The nausea and shock produced by the anesthetic are dependent not only on the length of time the drug is administered, but also on the amount that is given. The least possible quantity to enable the surgeon to do his work continuously and satisfactorily is the proper amount.

Some stages of an operation are extremely painful, while others cause but little discomfort. An experienced anesthetizer should learn by observation at what stage of an operation to have the patient profoundly under the anesthetic, and at what stage he can be allowed to partially come from under its influence.

Sometimes, through an error of judgment or owing to the development of unexpected complications, the patient may not be in a condition for the surgeon to continue his work. It then often happens that he peremptorily orders the anesthetizer to give more of the anesthetic. His orders should be taken *cum grano salis*, for they do not relieve the man behind the mask of his responsibility. He should do what he thinks best or give up the case.

It is better for the anesthetizer to watch for symptoms and prevent them than to have frequent recourse to tongue forceps, the oxygen tank, or other restoratives. From the beginning of the administration, he should watch for signs of danger. His attention should never be diverted by any incident of the operation. It is well to watch the character of the pulse, but it is far more important to watch the respiration, and above all, the face, as the earliest indication of danger. A rapidly dilating and fixed pupil is a danger signal, while a pupil contracted to normal size or a little less indicates surgical anesthesia.

The occurrence of sudden pallor or change in the pulse rate, lividity of the face or embarrassed breathing, indicates danger and calls for the immediate withdrawal of the anesthetic. A single additional whiff may mean the difference between life and death. If the patient does not breathe properly, the anesthetizer should put his fingers at the angle of the jaw and push it forward and upward. If this does not answer, the tongue should be caught with a piece of gauze and pulled up towards the nose, a little to one side. Bruising and lacerating the tongue with forceps is a barbarous practice. It should be remembered that there may be movements of the chest similar to the normal, though the glottis is closed and no air is entering the lungs.

Should the patient appear likely to vomit, his head should be turned to one side and the anesthetic withdrawn until the nausea disappears. If vomiting occurs, remove any ejected matter left in the mouth and continue the anesthetic.

If, during the operation, the patient shows evidence of having fluids or solids in the stomach, it is well at the completion of the work, to wash out the stomach with saline or weak bicarbonate of soda solution.

The anesthetizer beginning the administration should continue it until the completion of the operation. When a second anesthetizer takes the case with the patient under the influence of the drug, he is at a disadvantage in that he is not familiar with the condition of the patient in the earlier stages of the anesthetic.

NITROUS OXIDE.

Nitrous oxide gas, N_2O, or laughing gas, is a colorless gas, with a slight sweetish taste and smell. It is purchased in tanks, and administered by means of a special apparatus. It produces anesthesia in less than a minute, and recovery is equally rapid when it is withdrawn. It is sometimes followed by a headache, but rarely, if ever, by nausea. It is the safest anesthetic known, as only 14 deaths are recorded from four or five million administrations. Until recently, the agent has been used principally by dentists, but it is now being more extensively employed by the general surgeon.

The objection to it is the short period during which anesthesia can be maintained, the complicated apparatus necessary to give it, and the cost of the gas. It does not give complete relaxation, and cannot, for this reason, be used for operations on the rectum or perineum, as the patient cannot be kept in the lithotomy position owing to the rigidity of the legs. It is frequently employed as a preliminary to ether, in order to avoid the unpleasant sensations to the patient, and it is also used to open abscesses and bone felon, to break up adhesions of joints, to reduce dislocations, to remove gauze from the abdomen, and to dress painful wounds.

ETHYL CHLORIDE.

Ethyl chloride, (C_2H_5Cl), under pressure, is a colorless, volatile liquid, which boils at 54.5° F. It is very inflammable. As a general anesthetic, it is rapid in its effects, anesthesia being produced in from 30 seconds to 3 minutes, which lasts from one to three minutes, is recovered from rapidly, and as a rule, without any unpleasant after-effects. Since its discovery, opinion as to its merits has varied from time to time, it being alternately condemned and again, more or less generally recognized as a valuable agent. At present, the tendency is to regard it as not nearly so safe as nitrous oxide, though safer than chloroform or ether. Ware reported 12,436 cases, with one death; Seitz, 16,000 cases, with one death, though within the last few years there have been several deaths in one city attributable to the drug. Its place in surgery is as a substitute for nitrous oxide when this agent is not at hand. Its advantages are its safety as compared with chloroform, the ease and simplicity of administration, and the fact that no cumbersome apparatus is necessary. Infants and the aged take the drug as well as young adults. For some operations the anesthetic may be administered and withdrawn and re-administered over and over again for from 10 to 30 minutes. Respiratory obstruction is regarded as a contraindication.

It may be given either through a specially constructed mask or sprayed on gauze placed over the nose, exactly as ether is administered by the open method. As a rule, it does not produce complete muscular relaxation; often the pupils never dilate; the conjunctival reflex is rarely abolished, and the laryngeal reflex is said to be always retained.

HYOSCINE—(SCOPOLAMINE) MORPHINE ANESTHESIA.

Hyoscine and scopolamine are identical substances, and to produce general anesthesia, this drug is combined with morphine and administered hypodermically in doses of one-sixth grain of morphine and one-hundredth grain of hyoscine, freshly prepared, and given in divided doses, one hour and one-half hour, respectively, before the beginning of the operation. It may be given in three doses, the third dose being administered at the beginning of the operation. The method has been enthusiastically praised, just as enthusiastically condemned, and as yet has not received a definite place among anesthetic agents. Large doses are certainly dangerous, and if the drug is used at all, it should be given only as an aid to anesthesia, and never in sufficient amounts to produce complete narcosis of itself. There have been reported many deaths undoubtedly due to the drug, and it should never be administered to a patient with pulmonary edema or with any acute condition of the throat which interferes with respiration; nor should it be given to patients under 16 or over 60 years of age. Used as a preliminary to anesthesia, the amount of chloroform or ether required is considerably diminished, the post-anesthetic sleep prolonged, and in the few cases in which we have used the method, no special after-effects were noted.

If symptoms of poisoning occur, the treatment is that of morphine and hyoscine poisoning.

LOCAL ANESTHESIA.

Local anesthesia may be produced by cold, or by the application or injection of cocaine or some similar drug.

Cold. Cold may be employed by applying ice to the skin, or spraying the part with ether, ethyl chloride, or some other agent which evaporates rapidly. The method is of limited value, as its use is attended by considerable pain, and the tissues are made so hard and resisting that they are difficult to penetrate with an aspirator or to divide with the knife. It should be needless to say that freezing is not logical as a preliminary measure to the use of the actual cautery. Cases have been known, however, where a surgeon used ethyl chloride on a chancroid before he cauterized it with a hot iron.

Cocaine. Cocaine is the active principle of *erythroxylon coca.* The preparation usually employed is the hydrochloride of cocaine, a white crystaline powder, readily soluble in water. It is used by applying it externally to mucous surfaces, or by injecting it hypodermically into the skin or deeper structures. It acts more promptly and efficiently when the solution is warm and contains sodium chloride to make it isotonic, and adrenalin to cause local constriction of the blood vessels and prevent its rapid absorption and removal from the field of operation. Solutions of cocaine are unstable, and deteriorate if kept for any length of time, or if exposed to any extreme of heat. They should, therefore, be made fresh for each operation, and should not be boiled. There are tablets on the market containing cocaine and adrenalin, which can be sterilized by putting them in a tube, plugging both ends with cotton, and subjecting to dry heat. By dissolving one of these tablets in a definite amount of normal saline solution, the surgeon can readily and quickly extemporize a solution of the strength required for the case in hand.

Cocaine in toxic doses acts as a cardiac and cerebral depressant, and produces death by paralysis of the heart. The best antidote to its action is amyl nitrite by inhalation, or nitro-glycerine by hypodermic injection. It has been found that the danger of poisoning is not so much due to the amount of the drug introduced, as to the strength of the solution employed. Cocaine forms a combination with the protoplasm of the cells which is fairly stable and breaks down only after some time. If a weak solution is used, the cocaine combines with the tissue at the point of injection and has only a local action. It is only when a strong solution is employed that the drug reaches the general circulation and acts on the higher centers. The danger of its constitutional action is further lessened by the addition of adrenalin, and is practically eliminated when it is possible to arrest the circulation in the field of operation by the application of a rubber constriction.

Local anesthesia may be effected with cocaine by four different methods:

(1) *External Application.* This is possible only when the surface is covered with mucous membrane, and is especially suited to operations on the eye, nose, throat and urethra. Usually a 4 per cent aqueous solution is employed. It may be dropped in the eye; sprayed in the nose or throat; or applied to the urethra on a bit of cotton.

(2) *Infiltration.* This is employed to anesthetize the skin and subcutaneous structures, and is effected by injecting 0.1 per cent of cocaine solution into the part by means of a large hypodermic syringe. The "Sub-Q" syringe is a cheap and effective instrument, and should form part of every surgeon's armamentarium. It has a glass barrel and an asbestos piston: hence can be boiled

without injury. In infiltrating the skin, the point of the needle should be introduced obliquely into, but not through, the skin, so that the solution will be intracuticular, but not subcuticular. As soon as two or three drops are injected, a white wheal results. The needle should then be withdrawn and re-introduced at the margin of the wheal in the direction of the proposed incision. As soon as the skin is insensible, it should be divided, and the deeper structures anesthetized by inserting the needle slowly and forcing a few drops of solution ahead of it as its point advances.

(3) *Nerve Blocking.* This consists in injecting a few drops of 1 per cent solution of cocaine directly into the trunk of a sensory nerve, thereby, for a time, abolishing its function. The method is sometimes employed in amputations before dividing large nerves, to avoid shock, but its principal and most successful application is in certain major operations like the radical operation for hernia, where the nerve supply of the part is such that the branches can be isolated and injected, thus rendering it possible to do extensive work absolutely without pain or discomfort to the patient.

(4) *Spinal Anesthesia.* This is effected by injecting 10 or 15 drops of a 2 per cent solution of cocaine into the subdural space of the spinal canal. A needle is introduced one-fifth of an inch to the right of the spinous process of the fourth lumbar vertebra and forced forward, upward and inward for 2½ to 3½ inches, until the cavity is reached, which can be demonstrated by the escape of crebro-spinal fluid. The method causes paraplegia from the diaphragm down, which lasts about 45 minutes. Anesthesia is so complete that amputation of the thigh, hysterectomy, or prostatectomy can be done practically without pain.

Many substitutes have been offered for cocaine, notably eucaine but cocaine has held its place and increased in popularity.

The advantages of operating under local anesthesia are the freedom from the danger of a general anesthetic, and the absence of nausea and vomiting which so often follow its use. There is also less need for trained assistance. A man in the country, with a hypodermic syringe and a case of pocket instruments, can safely and satisfactorily operate on a case of strangulated hernia, with only the help which can be rendered by members of the household.

The disadvantages of operating with local anesthesia are that it takes more time, which is a bar to its routine use in a busy clinic; that it imposes a greater strain on both patient and surgeon, the one afraid of being hurt, and the other finding it necessary to constantly reassure him or divert him; and finally, that if the operator meets with unexpected complications or experiences any unusual difficulty in doing the work, the patient will recognize the fact and not be disposed to be charitable in his immediate or subsequent criticisms. The successful use of cocaine in major operations requires a personality to inspire confidence, a thorough knowledge of anatomy, and an ability to do clean dissection without injuring or bruising tissue.

LECTURE L.

THE INFLUENCE OF THE GENERAL CONDITION OF THE PATIENT ON THE RESULT OF A SURGICAL OPERATION.

There are some operations, such as for the relief of a strangulated hernia or the removal of a gangrenous appendix, which are so urgently demanded for the immediate purpose of saving life, that the surgeon has no choice and nothing is considered but the one great need. These are imperative operations, and must be done regardless of risk. There are other operations, such as for the correction of deformities or the relief of some chronic ailment, which, however desirable, are not essential to the life of the patient. These are elective operations, and should not be undertaken without carefully considering the danger to be incurred on the one hand, and the benefit to be hoped for on the other.

In estimating the risk of an operation, the modern surgeon is too apt to base his opinion on the statistics contained in text books and encyclopediæ. Figures are proverbially unreliable. Thus, for instance, the statistics of old operations such as ligations and amputations, are usually a record of pre-antiseptic surgery and do not represent the work of today. While the statistics of more recent operations such as thyroidectomy or gastroenterostomy, are usually the record of master-workmen and do not represent the danger of these operations in the hands of the average surgeon.

In deciding whether or not to advise a patient to undergo an elective operation, the following factors should be considered:

First, the Gravity of the Operation and the Relief to be Expected from its Successful Issue. There is no operation devoid of risk, and some are attended by great danger. Patients are occasionally unreasonable and insist on having a serious operation done to rid themselves of a more or less fancied ailment. Unless the operation is safe and there is a reasonable assurance of the patient being materially benefited, he should not be subjected to an elective surgical ordeal.

Second, the Ability and Experience of the Operator. No courageous doctor should fail to undertake an operation if the patient's condition is urgent, if delay means death, and if no more experienced surgeon is available. Competency is a relative term, and the man on the ground should endeavor to afford relief or else he fails to measure up to his responsibility. It is different, however, when the disease is a chronic one, and the patient could safely be moved to a hospital, or await the arrival of a competent surgeon from a neighboring city. A patient is entitled to the best possible prospect for prolonged life or restored health that his resources permit. No conscientious surgeon should undertake an operation without asking himself whether he has the skill to do the work satisfactorily. In many cases he can honestly answer the question in the affirmative. In some cases, while there may be a doubt in his mind, he is justified in operating by the fact that the patient has not the physical strength to bear transportation or the financial means to bring a surgeon from a distance. In other cases, however, the surgeon must recognize his inferiority to other men in the profession who devote their lives to special lines of work, and when the patient has the physical and pecuniary power to secure their services, it is his duty to place the case in their hands. This obligation is so universally recognized that the sacrifice it entails is not often appreciated by the laity, and sometimes not by the class of the profession which is benefited.

Third, the General Condition of the Patient, or the consideration of the personal factors in the individual case which influence the result of the operation. It is often said—sometimes seriously, sometimes satirically, and sometimes truly—that the operation was a success, but the patient died. In such a case, the indications for the operation may have been plain, but the contraindications were either overlooked or disregarded. The operation may have completely corrected the condition from which the patient suffered, it may have been perfect in its technique and brilliant in its execution, but the patient may have lost his life from some complication which could have been foreseen by more careful preliminary investigation. Many surgeons have had uncontrollable hemorrhage to follow the removal of a small tumor, owing to the patient having hemophilia, or have had gangrene develop in a wound, owing to the existence of diabetes, or have had suppression of urine to follow, owing to the presence of nephritis.

Sir James Paget, in one of his classical lectures, says: "Never decide upon an operation, even of a trivial kind, without first examining the patient as to the risk of his life. You should examine him with at least as much care as you would for life insurance. It is surely at least as important that a man should not die or suffer serious damage after an operation as that his life should be safely insured for a few hundred pounds."

Two separate and independent examinations should be made of every surgical patient—the first for the purpose of diagnosis and the determination of the condition to be corrected; and the second for the purpose of prognosis, or the determination of the safety of the operation. In forming an estimate of the latter, many factors have to be taken into consideration, such as age, sex, race, habits of life, constitutional diseases and visceral disorders. In discussing these under separate headings, much use has been made of an article by Sir Frederick Treves, who acknowledges a similar indebtedness to the writings of Sir James Paget.

Age. As a general proposition it may be stated that patients at either extreme of life are poor subjects for surgery.

Children under five years of age take anesthetics badly, often suffer severe shock from only moderate loss of blood, and are difficult to manage during convalescence. They are liable to gastrointestinal disturbances, especially in hot weather, and frequently are the victims of chicken-pox, measles or other infectious diseases to which they are susceptible. On the other hand, owing to the energetic cell activity of the period of growth, their tissues heal rapidly and are not prone to suppuration. In operating on children, avoid, if possible, the period of first dentition, as they are liable to digestive disturbances and to convulsions, and apt to develop a high temperature from slight provocation. Use chloroform as an anesthetic, and avoid the infliction of long-continued pain. Especial care should be taken to prevent loss of blood or body heat. Dressings should be carefully watched and changed as often as soiled. Usually no attempt should be made to keep the child in bed, but, from the first, it should be permitted to lie on the mother's lap or be carried about in her arms.

The period from the fifth to the fifteenth year is the golden age of surgery. Here the mortality is least, and the results best from operations of almost every kind. This is due to the fact that metabolic processes are active and resistance to infection vigorous; that the various organs of the body are normal and perform their functions satisfactorily; that the nervous system is stable and uninfluenced by regrets for the past or fears for the future; and finally, that the reason and will of the patient have developed sufficiently for the surgeon to secure their acquiescence and co-operation.

Between the twentieth and fortieth years the mortality of operations greatly increases. This is due to sexual development, attended by the possibility of excesses, abnormalities and diseases; also to the cares and responsibilities of maturity, often leading to neurasthenia from excessive work and worry. And finally, there may be superadded the injurious results of addiction to tobacco, whiskey or other drugs and of other forms of dissipation.

In patients past 40 years of age the mortality from operations is nearly three times greater than in patients under 20. As a rule, old people are severely shocked by loss of blood or body heat; their wounds heal slowly, and their tissues have little power to resist infection. They are headstrong and rebellious, and intolerant to confinement. Their organs of assimilation and excretion are impaired, and their stomachs and kidneys liable to break down. Taken all in all, old age is a greater bar to surgery than any other complication, unless it be chronic alcoholism. It must be remembered, however, that senility is not measured in years. Surgically speaking, a man is as old as his arteries. In impressing this point, Sir James Paget says: "They that are fat and bloated, flabby of texture, torpid, wheezy and incapable of exercise, looking older than their years, are very bad.

"They that are fat, florid and plethoric, firm skinned and with good muscular power, clear headed and willing to work like younger men, are not, indeed, good subjects for operations, but they are scarcely bad.

"The old people that are thin and dry and tough, clear voiced and bright-eyed, with good stomachs and strong wills, muscular and active, are not bad: they bear all but the largest operations very well."

The brilliant results of Young and others in operating on old men for prostatic enlargement, show that modern surgery, with its short period of anesthesia, diminished loss of blood, freedom from infection, and provision for adequate drainage, has made it safe to do operations on the aged which, only a short time ago, would have been unjustifiable.

Sex. Other things being equal, women bear operations better than men. This is due to the fact that they are designed for maternity and are naturally endowed with more passive endurance; that they are more confiding and trustful, and place greater confidence in the assurances of the surgeon; that they are more tolerant to confinement to bed, because they are not accustomed to active out-door life; and finally, they are more temperate and regular in their lives, and not as frequently the victims of excesses in food and drink.

On the other hand, menstruation, pregnancy, lactation and the phenomena of the menopause give to the sex the possibility of complications to which the male is not subject. As a rule, operations should be avoided during menstruation, as the period is frequently attended with nervous and digestive disturbances. The time of election, especially in gynecological work, is the two weeks midway between the completion of one period and beginning of the next. In emergencies, however, an operation may be done during menstruation without misgivings, as usually no ill effects result.

It is also undesirable to do an operation of election during pregnancy, as it entails the possibility of miscarriage and of kidney [illegible]. The danger is more theoretical than real, however, as hundreds of abdominal sections have been done on pregnant women, for appendicitis and other abdominal diseases, without interference with gestation.

It is also inadvisable to operate during lactation, because the woman's strength and resistance are below par, and if she continues to nurse the child, she will have an undue tax upon her, while if she ceases to do so, there will be the danger of trouble with the breast.

Race. The influence of race on the result of an operation is a question of interest, but not of great practical value. It is stated that a Chinaman makes the best patient on earth. In America, especially in the Southern States, there is good opportunity to contrast the respective resistance of the Caucasian and the Negro. Surgeons of large experience in operating on both races are practically unanimous in the opinion that the black man is a better subject than the white man. This does not apply to the mulatto, for he follows the rule of the mongrel, and has the vices of both parents and the virtues of neither. It is obvious even in the life of an individual that the pure negro is losing the immunity, formerly enjoyed, to certain diseases and is developing predispositions which render him a less favorable subject for operation. Before the Civil War, insanity was almost unknown in the race; tuberculosis was not common; and venereal diseases of rare occurrence. With civilization, education and syphilization, he is now the victim of various nervous disorders; with unhygienic surroundings and scant clothing, he is a frequent victim of the Great White Plague; and with improper food, eaten at irregular intervals, his digestion has become impaired, and he is suffering more and more frequently from gallstones, appendicitis and diseases of the kidneys. The day will come when the degeneration of the whole race will have reached a point to make it an accepted fact that they are poor subjects for surgical work.

Vigor and Weakness. Paradoxical as it may sound, the strong, robust man frequently does not make as good a surgical patient as one who is feeble and wasted by disease. He may have huge limbs and mighty strength; he may never have had an illness in his life, and boast of the constitution of an ox, but he is a poor subject for the surgeon's knife. He is accustomed to fresh air and an active life; his blood vessels are full and oxygenation of the tissues is rapid. His food has been large in quantity and gross in quality. When misfortune overtakes him, there is no time to accommodate himself to new conditions, and the whole habit of his life is suddenly changed. To this is added the shock of his accident, the horror of an operation, and the dread of the future. Just the contrary is true with the chronic invalid, who has been acclimated to bed life by long weeks of invalidism, whose circulation, respiration and digestion have become adjusted to his condition, and who has been brought to view the approaching operation as a means of relief of pain and restoration to health. Of the two types described, the last will be well first.

Obesity. As a rule a fat patient is a bad patient. If the obesity is hereditary and the general health good, it is not as bad as when the fat is due to gluttony, indolence or beer-drinking. An obese patient is an elephant on your hands. He usually breathes with difficulty and cannot assume a recumbent position. It is hard to move him in bed, and difficult to prevent the formation of bedsores. The skin is usually thin from pressure, and its edges difficult to approximate. The subcutaneous fat has little vitality and readily breaks down and liquefies. Infection once taking place, pus burrows far and wide, and is drained with great difficulty. Sometimes such patients die suddenly from fat embolism: again they become exhausted and prove an easy victim to intercurrent diseases. If recovery takes place, convalescence is always tedious and prolonged.

Alcoholism. The most unpromising patient who ever comes to a surgeon is the chronic alcoholic. Constant drinkers who are never drunk, and yet who are never sober, are worse subjects than those who get on periodic sprees. The gravity of the risk in the individual case will depend on the length of time the individual has taken stimulant; the average amount consumed daily; the presence or absence of tremor of the hand or alteration of the knee-jerk; the existence of gastritis, as indicated by anorexia, nausea or vomiting; and the condition of the liver, kidneys, heart and blood vessels. No operation except the most imperative should be done on the alcoholic, because of the danger of the administration of the anesthetic, because of the depraved conditions of the tissues and consequent lack of resistance to infection, because of the liability of the kidneys to stall or the heart to run away, and because of the danger of the development of wild and uncontrollable delirium. When an operation is unavoidable, but not immediately necessary, the patient should be prepared for it by diminishing or withdrawing the stimulant. When an immediate operation is necessary, it is better to continue the alcohol until the period of greatest danger is past.

Affections of the Nervous System. Hysterical patients usually give a great deal of trouble before the operation, but do very well after the ordeal is over. A nervous woman who wishes to tell of the unfortunate surgical experience of her friends, who desires to discuss every step and detail of her own operation and tell how she wishes her case managed, and who is possessed of exaggerated fears as to the complications which may develop or the ultimate result which may follow, usually, after the operation, becomes a model patient. Her imagination enters upon fresh fields and she becomes hopeful and courageous, and at once begins to plan a new life of activity.

The neurasthenic, however, is a different subject, and woe betide the incautious surgeon who operates on one. Occasionally neurasthenia may be due to chronic appendicitis, uterine displacement, or some other cause which can be corrected, and the patient cured. But in a large majority of cases the neurasthenia is due to a disturbance of the general body nutrition, and no operation will prove of benefit. The vicitim of neurasthenia wears out the patience of his family and friends, and in order to secure a sympathetic listener, and in order to demonstrate to the community the serious nature of his disease, he goes from surgeon to surgeon and from hospital to hospital, offering himself as a bloody sacrifice to his curious form of egotism, and glorying in his martyrdom. Surgery does this class of patients no good, but deepens, rather than relieves, the neurasthenia.

The insane are usually good subjects for surgical operation.

The regular life of an asylum is conducive to good health, and the absence of mental anxiety on the part of the patient is a favorable factor. Mayo, who has done a great deal of work on this class of cases, states that they are entitled to just the same surgical treatment as the sane—no more, no less. In other words, insane people should be operated on to relieve them of hernia, gall stones and abdominal tumors, but hernia, gall stones and abdominal tumors should not be operated on to cure the patient of insanity.

CONSTITUTIONAL DISEASES.

Rickets is a condition of bony malnutrition. If the general health is good, wounds heal as well in rickety subjects as in other cases.

Syphilis does not usually increase the risk of a surgical operation. Wounds made during the full bloom of the secondary stage heal kindly, and operations done on tertiary lesions usually do well. The danger in operating in the early stages of syphilis is rather one to the surgeon than to the patient, as the blood is infectious.

Gout has no effect upon the result of an operation, unless it has existed sufficiently long to produce cardiac or renal changes. It is, of course, not wise to operate during an acute attack of the disease, and it must also be remembered that an operation sometimes precipitates an attack in a person predisposed to the disease.

Hemophilia contraindicates a surgical operation, unless urgent and required to save life. Fortunately the subjects of hemophilia do not always bleed. A case is in mind where a man was brought to the hospital with gangrenous appendicitis, and who gave a history of having suffered repeatedly from almost fatal hemorrhage after trivial injuries. After consultation, a section was determined on as the only hope for life. It was performed with less than the usual loss of blood.

Malaria and an injury or operation have a reciprocal relation one with the other. Malaria may cause pain, hemorrhage or inflammatory changes at the site of injury, which assume an intermittent type and yield to administration of quinine. Again, an injury or operation inflicted on a person the victim of malaria may markedly aggravate the disease, or induce a fresh onset of ague; or again, it will make active symptoms in a person who is not known to be infected.

Diabetes is a contraindication to an operation of election. The tissues of a diabetic patient possess little power of regeneration, and have so little resistance to infection that inflammation, suppuration and gangrene are almost certain to develop. Surgery on diabetics should only be done when most imperatively demanded, as often when the sugar in the urine has been decreased to an insignificant amount by weeks of diatetic treatment, it will reappear in large quantities immediately after the operation, and the patient die in diabetic coma.

VISCERAL DISORDERS.

Cardiac and Vascular Diseases. Valvular disease of the heart is believed by the laity and by most of the profession, to add greatly to the risk of the anesthetic and to the danger of death from complications following the operation. This does not seem substantiated by facts. Many thousands of patients with valvular heart disease are operated upon every year and it is exceedingly rare that any bad effect is produced; and but a very small proportion of the patients who do die from chloroform or ether are found to have been the victim of organic heart disease. So far as convalescence after the operation is concerned, patients with heart trouble are usually markedly improved by the enforced rest and confinement to bed. A dilated or fatty heart is much more to be feared than one with valvular lesion, especially if there be adequate compensation. In all cases though it is the duty of the surgeon to recognize and properly treat these patients to guard against failure of compensation.

Atheroma of the Arteries was formerly thought to predispose to secondary hemorrhage, but in modern practice this complication is rarely, if ever, seen. The complication to be most dreaded from disease of the arteries is gangrene due to lack of nutrition of the tissues to which they are distributed.

Renal Diseases. It was formerly thought that the presence of albumen or casts in the urine indicated grave organic change in the kidney, and was a bar to surgery. This may have been the case with the crude tests of the older pathologists, but it is certainly not so today, for the modern laboratory man finds albumen and casts in a great proportion of the specimens submitted to him. Dr. Osler has emphasized this in a recent article entitled, "The Advantages of Having a Few Casts in The Urine after a Man Reaches Sixty Years of Age." Certain forms of nephritis, however, add greatly to the danger of an operation, and all surgeons occasionally lose patients from suppression of urine, followed by uremic convulsions. No operation of election should be done on a patient suffering with advanced Bright's, and when the urgency of the case is such that an operation has to be done, the patient should be carefully prepared by dietetic and eliminative treatment before the operation, and the kidneys kept active afterwards by the use of spartine and the administration of large quantities of water by mouth or rectum.

Respiratory Tract. Bronchitis, pneumonitis and phthisis pulmonalis are serious bars to surgery, inasmuch as they make the administration of the anesthetic difficult and dangerous, and complicate the after-treatment by coughing, embarrassed breathing and imperfect oxygenation. In acute inflammation of the lungs, operations should be postponed, and in chronic trouble, they should not be done except to meet real indications.

Alimentary Tract. Gastric dyspepsia, intestinal indigestion, diarrhea and constipation are all conditions to be corrected prior to an operation. The prognosis is bad when to the toxins of disease, is added the poison produced by putrefaction of gastric and intestinal contents. In correcting the conditions named, food should be sterilized, the mouth should be repeatedly disinfected, the stomach should be properly irrigated, and intestinal antiseptics, together with purgatives, should be judiciously administered.

In disease of the liver, especially when the patient is jaundiced, the danger of hemorrhage should be determined by testing the coagulability of the blood, and, except in cases of great urgency, operations should be postponed until the cholemia subsides or until, by the administration of calcium chloride or other drug, the danger of uncontrollable bleeding be removed.

Diseases of the Blood. Anemia, or a deficiency of either hemoglobin or red blood cells, is often a contraindication to an operation. Mikulicz states that a hemoglobin percentage below thirty, or a red blood count below 3,500,000, should postpone operative intervention until the blood is enriched by medical treatment. While this is a safe rule to follow, it has its exceptions. The lives of women have often been saved by hysterectomies whose blood findings were below this minimum owing to profuse and uncontrollable uterine hemorrhage.

Leucocytosis, or increase in the polymorphonuclear leucocytes, especially when progressive, indicates advancing suppuration and demands early operation.

Leucocythemia, contraindicates all operations of election. The patients usually die after operations of great magnitude and stand in great peril after more trivial procedures from hemorrhage, infection and other complications.

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